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Laser Angle Sensor

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ABS: A laser angle measurement system was designed and fabricated for NASA Langley Research Center. The instrument is a fringe counting interferometer that monitors the pitch attitude of a model in a wind tunnel. A laser source and detector are mounted above the model. Interference fringes are generated by a small passive element on the model. The fringe count is accumulated and displayed by a processor in the wind tunnel control room. This report includes optical and electrical schematics, system maintenance and operation procedures.

ENTER:

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LASER ANGLE MEASUREMENT SYSTEM

I. INTRODUCTION

This document is the final report on contract NAS1-16546. The document covers the system configuration, operation, and alignment of the Laser Angle Sensor for the National Transonic Wind Tunnel.

The Laser Angle Sensor is designed to measure the pitch attitude of a model in the National Transonic Facility (NTF). The sensor consists of an optical unit (above the test section), a retroreflector assembly (on the model), a thermal control chassis (outside the entrance to the test section), and an electronic processor (in the control room).

The operation of the sensor is based on optical interference. The optical unit projects a set of laser beams onto the model. The retroreflector assembly generates interference fringes, where the fringe spacing is a function of wavelength. Two laser wavelengths are used to provide an unambiguous phase difference over a 40 degree model attitude. This allows update of the absolute pitch attitude following loss of signal due to nitrogen fog or other circumstances.

The lower part of the optical unit contains a beam pointing assembly. This capability is required in order to keep the measurement beam centered on the model retroreflector assembly as the tunnel expands and contracts and as the model attitude changes. The range of the pointing assembly is approximately 20 degrees in either direction from the vertical axis.

II. OPTICAL/MECHANICAL ASSEMBLY

The optical/mechanical assembly consists of an upper optical unit that contains the helium-neon and gallium arsenide lasers, a temperature controller for the diode laser, beam combining and scanning optics, signal and reference beam detectors, and buffer amplifiers for driving the cables to the control room. The upper unit is designed to operate at room temperature and with one atmosphere pressure. Flowing nitrogen gas is used for cooling when the tunnel runs hot. Film heaters on the inner walls are used to heat the unit when the tunnel is cold. Optical and electrical damage can occur if the environmental conditions are not controlled. Some potential effects are delamination of the interference filters, breakage of the glass windows on the detectors, failure of the electronic components, motor bearing failure, and decreased lifetime of the diode laser.

The lower optical unit contains the beam pointing hardware, the laser beam collimating optics, the reference reflector (for measuring the exit beam angle), a small reference mirror (to provide an electrical phase reference), an oscillating mirror (for reacquisition of absolute angle), a muffin fan, and an exit window. The lower unit has temperature control (via film heaters), but the pressure is not controlled. Three pressure windows couple the laser beams between the upper and lower units. Dry nitrogen purge gas is introduced at the top of the lower unit and exits through a gap on either side of the exit window.

Upper Optical Unit

Figure 1 is a plan view of the upper optical unit. The He-Ne laser beam reflects off of a pair of 45 degree mirrors into an anamorphic collimator. The He-Ne collimator consists of a double convex cylindrical lens to expand the beam into a fan in the horizontal plane and a plano-convex cylindrical lens to recollimate the fan beam. The collimator produces a beam that is approximately 25 mm wide and 2 mm high. The beam can be rotated by rotating the lens assembly. The collimation adjustment is made by sliding the small cylindrical lens mount in and out. Rotation of the small lens mount aligns the transverse axes of the two cylindrical lenses.

The diode laser is mounted on a heat sink supported by a pair of thermoelectric heater/coolers. The heat sink temperature is controlled by varying the magnitude and direction of the electrical current through the thermoelectric elements. The current through the diode laser is controlled to prevent excess heating of the output facets. The control electronics also includes provision to prevent damage to the laser during the turn-on transient.

The diode laser collimator is a 2-element system designed to minimize spherical aberration. A cylinder lens at the output end increases the length/width ratio of the beam to increase the optical efficiency. Beam collimation is adjusted by moving the laser assembly fore and aft in the mount. The height is adjusted by rotating the knurled knob at the diode laser end. Rotation of the other end rotates the laser itself. (Note that the two knurled elements do not have coincident axis. The eccentricity is

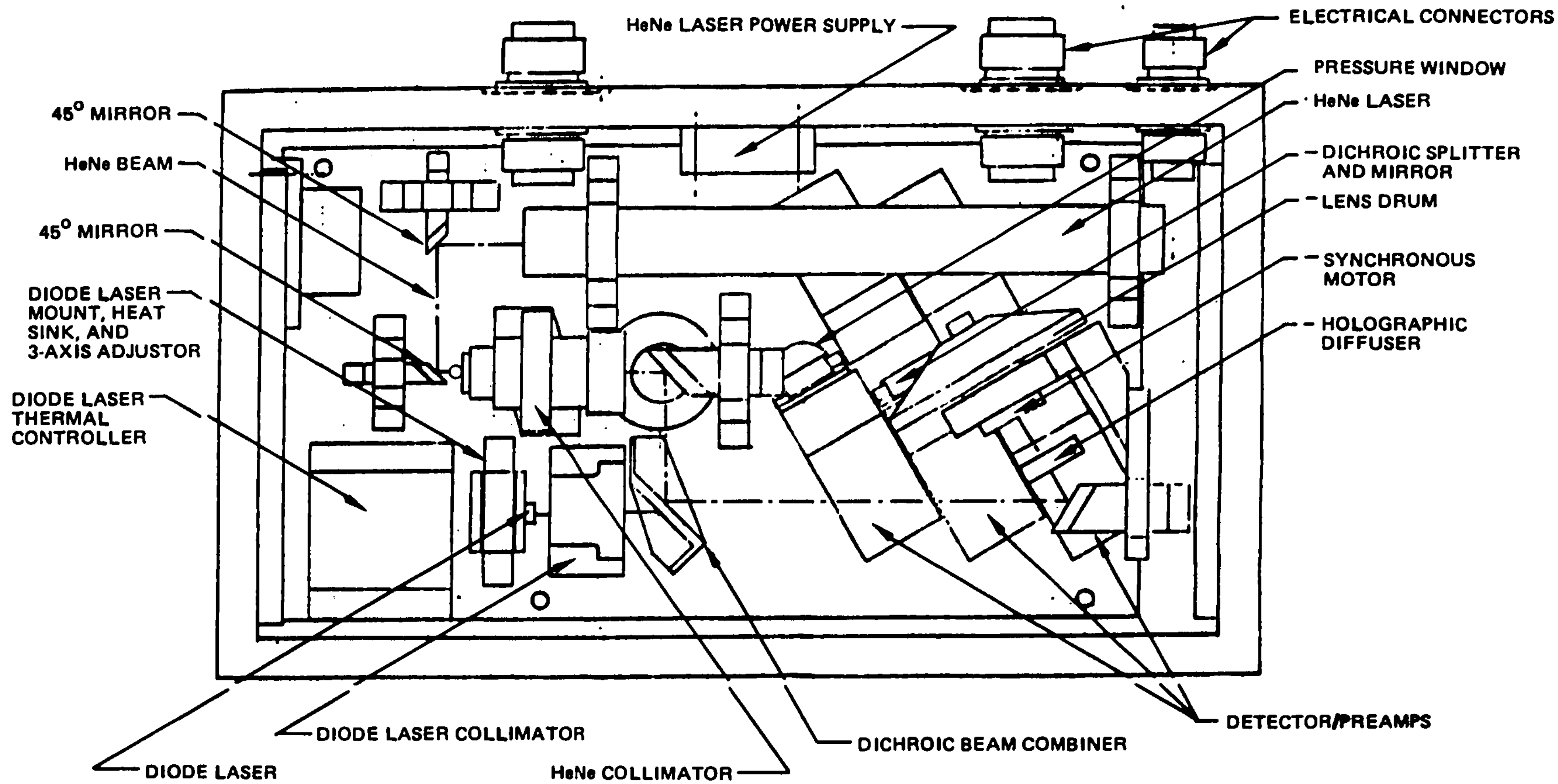


Figure 1: Upper Optical Unit

used for the height adjustment). Lateral adjustment by sliding the mount sideways is done after setting the proper height.

The two laser beams are combined with a dichroic filter that reflects He-Ne light and transmits infrared. Proper adjustment of the collimators, dichroic filter, and large 45 degree mirror results in a pair of beams that are superimposed both at the exit of the dichroic filter and at the holographic diffuser. A video camera is very useful for checking the alignment of the two lasers. The diode laser beam is invisible to the eye, but shows clearly on the monitor of a solid state or vidicon camera unit.

The combined beams are internally reflected at a prism below the motor mount. The holographic diffuser should be removed for initial alignment, as the beams should be centered in the rectangular aperture on the lower face of the prism. After reflection from the prism, the beams illuminate a row of lenses on the lens drum.

Adjustment of the beams at the lens drum should be done with the folding mirror near the holographic diffuser rather than by sliding the motor in its mount or by sliding the lens drum on the motor shaft. The position of the lens drum determines the location of all return beams relative to the detector aperture, so it should not be changed unless absolutely necessary. If the drum must be removed (such as for motor replacement), measure and record the lens drum to motor mount separation and the motor shaft end position relative to the drum. Reassemble to these measurements, then slide the motor very slightly to peak up the model reflector signal. Check to

insure there is no vignetting as the reflector is moved throughout the exit beam.

There are five detector/preamp boxes in the upper unit. These are for visible and infrared signal beams from the model, reference retroreflector visible and infrared beams, and for generating an electrical reference phase. The retroreflector returns (model and reference) impinge on dichroic splitters that reflect the He-Ne light into the detectors below the He-Ne laser while transmitting the infrared diode laser beams. Small mirrors above the dichroics reflect the infrared beams into the detectors. Interference filters with 3 nm bandwidths are located behind the aperture plates on the He-Ne detector boxes. The infrared detectors have RG 715 Schott glass filters. The reference detector has a rectangular mask at the entrance aperture that matches the lens spacing on the lens drum. There is no spectral filter in the reference detector box.

All detector boxes have a metal mask at their entrance aperture. The mask is located at the focal plane of the large collimating lens in the lower optical unit. Inside each box is a fast aspheric lens that images the collimating lens aperture onto the detector. This prevents vignetting of the marginal rays.

Lower Optical Unit

Figure 2 shows the lower optical unit. The input beams enter through a 76 mm pressure window at the top and propagate down to the 128 mm diameter F/5 collimating lens. The collimated He-Ne and diode laser beams are directed

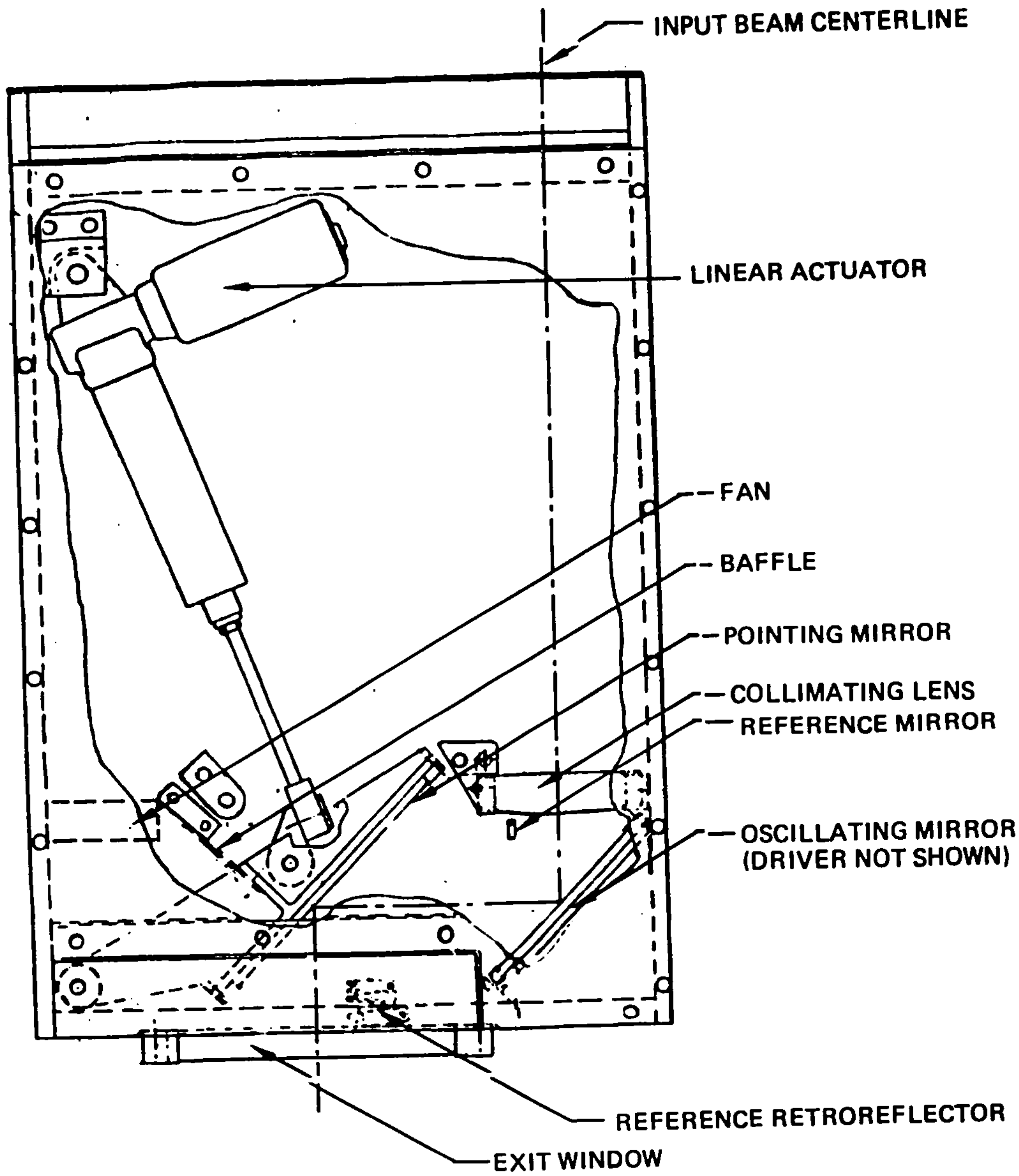


Figure 2: Lower Optical Unit

onto the model retroreflector with the two folding mirrors. The oscillating mirror is driven on demand through about 0.5 degrees by use of a motor and cam arrangement. This feature is used for removing the effect of dual wavelength phase nonlinearity during coarse angle reacquisition.

Both folding mirrors are gold coated for high reflection properties at both He-Ne and diode laser wavelengths. The gold coating is soft, so care must be exercised when cleaning. The recommended cleaning technique is the same as for laser cavity mirrors, i.e., place a lens tissue on the mirror, drip on a small amount of residue free solvent (acetone or alcohol), then drag the tissue off the edge of the mirror, using surface tension to hold the tissue onto the mirror. Cleaning is not required often, as the system was designed to operate reliably with quite a lot of visible dust and dirt on the mirrors.

The exit beam direction is controlled by the linear actuator and pointing mirror. The maximum angular change is approximately 20°. The direction of the outgoing beam is measured with the reference retroreflector. The reference retroreflector uses a 6° deviation prism to refract the reflected infrared and visible beams back through the collimating lens, through the center pressure window, and onto the reference reflector detectors. The reference hologram disc has an etched diagonal strip (on the glass surface) to prevent retroreflection into the signal detectors.

The small 3 mm square mirror positioned below the collimating lens provides an optical signal for generating an electrical reference with constant phase relative to the lens drum. The mirror is adjusted in two axes via a push-pull screw arrangement and rotation around the attachment screw. The

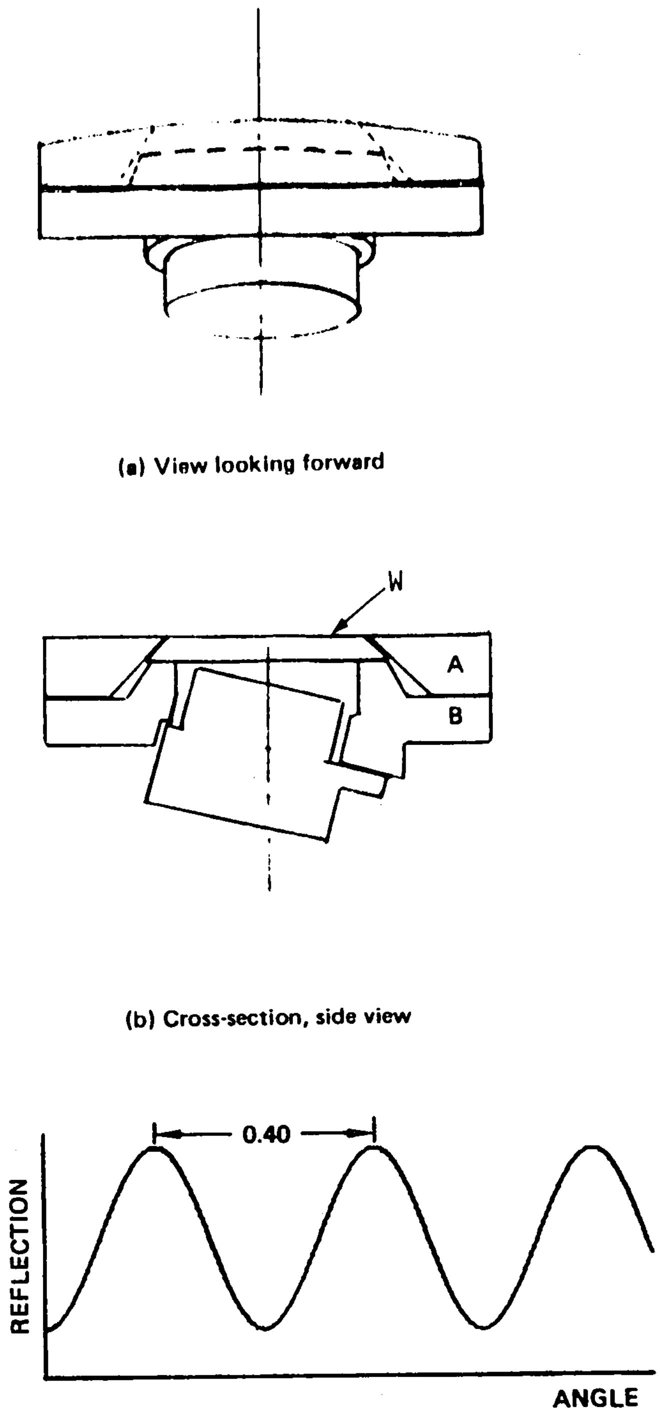
reflected beam passes through the third pressure window and reflects off of a small 45° mirror into the reference detector aperture.

Model Retroreflector Assembly

Figure 3 shows the retroreflector assembly designed for the Pathfinder I model. The window is a cylindrical lens designed for zero power (input and exit beams are collimated). Both the window and the hologram are cemented in place with Crest adhesive.

The hologram and cube-corner reflector are mounted on a wedge below the window. The wedge positions the reflector normal to the input beam when the model is horizontal. The wedge will not be required for models where the retroreflector is directly below the tunnel window.

Hologram installation and alignment is straightforward. An annular mask of vinyl tape with outer dimension that clears the mount is centered on the clean glass surface of the hologram disc. The center hole of the mask is one or two millimeters. A thin fillet of Crest is applied to the inside faying surfaces of the mount, then the hologram is pressed in place with a short length of 6 mm ID vinyl tubing. The tubing is also used to rotate the hologram and hold it in place while the adhesive sets. A low power He-Ne laser beam projected through the annulus generates higher order beams that indicate the clocking of the hologram. The hologram is rotated until the plane of the diffracted beams is normal to the flat spot on the mounting flange.



(a) View looking forward

(b) Cross-section, side view

(c) Reflection characteristics

Figure 3: Retroreflector Assembly

Window installation and alignment can be a difficult problem, so detailed instructions are listed below. The materials required are aluminum tape, black vinyl electrical tape, Crest adhesive, finger cots, cotton swabs and a small vacuum pump with a bell jar. Wear the finger cots to prevent contamination of the window surfaces. Clean all parts before assembly.

1) Cut a 12.5 mm diameter disc of electrical tape and apply to center of concave side of cylindrical window.
2) Set window on lower part of window mount (Part B). Rotate window to align with cylindrical surface of B.
3) Set Part A on Part B.
4) Rotate A to align cylindrical surface with upper surface of window. Overhead fluorescent lights work well for this alignment. Orient A so the fore/aft line is aligned with the long axis of the lamps, then raise A slightly and rotate B until the lamp reflection in the window is aligned with the fore/aft line.
5) Center the window in A then put a clean strip of vinyl electrical tape along the fore/aft of A and across the window.
6) Check the alignment of the cylindrical axis of W and A by observing refected light on the upper surface of the tape. Note that the shadows on the tape also allow easy determination of elevation of the window relative to the upper surface of A.
7) Insert paper shims to center the window in the hole in A. Unstick and pull the vinyl tape as required to move the window.
8) When the window is centered and aligned, place A on B and cover with a strip of aluminum tape. Turn over and roll on a flat surface, pushing gently on B, to bring the window surface into alignment with

mount A. Very small elevation errors can be detected by observing the aluminum tape surface.

9) Check the gap between the beveled window surface and the conical recess in A. Readjust and repeat 6) as required to center the window.

10) Mix a small batch of Crest adhesive.

11) Turn A upside down and pour 1 to 2 cc of Crest on the A/W gap.

12) Evacuate until adhesive bubbles up, repeat several times to fill the gap with Crest.

13) Remove the vacuum chamber and clean up excess Crest with cotton swabs.

14) Allow sufficient time for Crest to completely harden.

15) Gently remove tape, being careful to avoid high stress on the bond line. Remove with a peeling action, pulling parallel to the surface.

16) Measure the gap between the upper surface of A and the lower window surface by applying a known thickness (X) of vinyl tape to the mating surface, then measuring the edge gap (Y) between A and B. Subtract Y from X to determine the gap. Cut a teflon gasket of thickness X-Y. If X-Y is negative, put a gasket on B, then shim the edges of A and B as required.

16) (Alternate) Make a gasket of Crest between the window and B as follows: Protect the center with a vinyl tape disc with a tab, then apply a bead of Crest around the disc. Assemble A and B. Clean up the unused adhesive on the tape with cotton swabs. Remove the tape by gently pulling the tab parallel to the window surface after the Crest is cured.

Mechanical Stress Analysis

The upper optical unit is designed to be held at ambient pressure. The housing and optical windows must withstand the pressure differential between ambient and plenum pressure. Stress calculations are below.

The maximum stress in a uniformly loaded circular window is given by reference 1.

$$S_{max} = \frac{KD^2P}{4t^2}$$

where S_{max} = maximum stress

D = support diameter

P = pressure

K = constant depending on support

According to reference 2, a value of $K = 9/8$ is suitable for an unclamped optical window. Assuming a safety factor of 4, the thickness to diameter ratio for an unclamped window is

$$t/D = 1.06 \left(\frac{P}{Fa}\right)^{\frac{1}{2}}$$

where t = thickness

Fa = apparent elastic limit

If $P = 1.1$ MPa and $Fa = 69$ MPa (for fused silica),

$$t/d = 1.06 \sqrt{\frac{160}{10^4}} = .126$$

so the minimum thickness for the 50.8 mm window is 6.4 mm, and the minimum thickness for the 76.2 mm window is 9.6 mm. The windows used in the upper optical unit are 12.7 mm and 19.05 mm thick, approximately twice the required thickness.

The maximum stress and deflection occurs on the top plate of upper optical enclosure. The material is 6061-T6 aluminum, with elastic modules of 6890 MPa and tenile strength of 310 MPa. Reference 3 gives equations for maximum stress and deflection for a clamped flat plate with uniform loading.

$$\text{Max. stress} = \frac{wb^2}{2t^2}\left[\frac{1}{.623\ (b/a)^6 + 1}\right]$$

$$\text{Max. deflection} = \frac{.0284wb^4}{Et^3}\left[\frac{1}{1.056\ (b/a)^5 + 1}\right]$$

where a = length

b = width

t = thickness

E = elastic modules

w = load

The top plate is stiffened with a 25.4 mm x 50.8 mm aluminum beam welded to the underside of the plate. As a conservative case, we neglect the stiffener, then if the pressure differential is 1.1 MPa, the maximum

deflection is .31 mm and the maximum stress is 92 MPa. This is less than 1/3 the yield stress. The actual stress and deflection will be much lower due to the stiffener.

Hydrostatic Test Results

On December 16, 1981 a hydrostatic test was performed on the upper unit of the optical assembly. All holes on the upper unit were plugged. Hydrostatic pressure of 150 PSI gauge was applied to the inside of the upper unit and maintained for 15 minutes. No observable deflection was detected in the top, bottom or flanges and no leaks detected on the O-ring seals. This test represents a worst case test of the upper unit where all welds are tested in tension. In tunnel operation the upper unit is subjected to compression forces from the outside which are less severe than the internal forces from the hydrostatic test.

Angular Corrections Due to Tunnel Effects

There are four regions where variation in the index of refraction due to tunnel operating conditions can alter the beam angle.

1. Interior of lower optical unit - The temperature is controlled when the tunnel is cold but the pressure varies with the plenum pressure, so the refractivity is a variable. Both pressure and temperature are variables when the tunnel is hot, as there is no mechanism for cooling the lower optical unit except by conduction to the upper unit. (The upper unit is cooled with room temperature nitrogen gas).

2. Space between lower optical unit window and tunnel window - The temperature will be closed to the tunnel wall temperature. The pressure varies with plenum pressure.

3. Test section - The density field, acquired by measurement or modelling, should include the boundary layer on the tunnel wall.

4. Inside the model - Refraction at the inside of the model window and at the reflector assembly depend on the pressure and temperature of the gas in the model.

The index of refraction of the windows also changes with temperature, but this does not result in an angular error since the windows are planar and at uniform temperature.

The relation between index of refraction and density is

$$n \quad 1 + (n_S - 1)\frac{\rho}{\rho_S} \qquad (1)$$

where

n = index of refraction

n_s = index at standard conditions

ρ = density

ρ_s = density at standard conditions

The AIP Handbook lists the refractivity of nitrogen gas at several wavelengths, as shown in the Table 1.

Table 1 - Refractivity of nitrogen gas at standard conditions

λ(nm)	486.1	546.1	656.3
(n-1) x 1000 (0°C, 760 mm)	.3012	.2998	.2982

Interpolating and extrapolating with a best-fit line, n = 1.0002985 for 632.8 nm and n = 1.0002951 for 832 nm wavelength.

Snell's Law can be used to calculate the angular correction at each window due to gas density differences. The equations are listed below.

Lower unit window $\theta_{12} = i_2 - i_1 = (\frac{n_i}{n_2} \sin i_1) - i_1$ (2)

where θ_{12} = angular correction

i_1 = angle of incidence in region 1

i_2 = angle of incidence in region 2

n_1 = index of refraction in lower unit

n_2 = index of refraction in region 2

Tunnel window $$\phi_{23} = \left(\frac{n_2}{n_{3b}} \sin i_2\right) - i_2 \qquad (3)$$

where n_{3b} = index of refraction in boundary layer next to the window

Model window $$\phi_{34} = \left(\frac{n_{3m}}{n_4} \sin i_{3m}\right) - i_{3m} \qquad (4)$$

where n_{3m} = index of refraction in boundary layer above model window

i_{3m} = angle of incidence of beam entering window

n_4 = index of refraction of nitrogen gas inside model

The correction for flow in the test section is more complicated. The density in the boudary layer will probably be different than the free-stream desity, and the density may not be constant in the flow direction. The curvature of a ray propagating in a three-dimensional density field is

$$\frac{1}{R} = \frac{\sin\alpha}{n} \left|\text{grad } n\right| \qquad (5)$$

where R is the radius of curvature, grad n is the vector gradient of the denisty field and is the angle between grad n and the ray. The ray curves in the direction of increasing density. Since curvature is the change in direction of the tangent to a curve per unit distance along the curve, the total angular direction of a ray is

$$\phi_3 = \int_{\text{window}}^{\text{model}} \frac{\sin\alpha}{n} \left|\text{ grad } n \right| ds \qquad (6)$$

A sample calculation will illustrate the magnitude of the various correction elements. Consider the window on the optical unit. Assume the temperature inside the unit is 294^{o}K while the temperature in the space below the window is 100^{o}K. Assume 8 atmospheres pressure. If the angle of incidence of the beam on the window is 13^{o} (as expected for Pathfinder 1), then θ12 = -.057 degrees for the helium-neon beam and θ12 = 0.056 degrees for the gallium arsenide lasr beam. The difference for the two wavelengths is insignificant, but the .057 degree correction is important. Since the correction is only six times the resolution requirement, extreme accuracy in the estimation of the pressures and temperatures is not important. The density ratio in this example is approximately three. This is much greater than will be expected at either the tunnel window or the model window.

III. ELECTRONICS

Figures 4 and 5 are block diagrams of the electronic circuitry used in making phase measurements between four optical signals and an optically derived reference phase. Five alternating electrical voltages are generated by five photodetectors in the optical assembly. Two signals are derived from the model reflector and two from the reference reflector. As described in more detail elsewhere, the returns from both the model reflector and reference reflector consists of a visible and infrared light beam. The nominal frequency of the electronic reference is 2700 Hz with minimal amplitude and phase modulation resulting from imperfections of the rotating lens drum. The returns from the respective corner reflectors are also a nominal 2700 Hz modulated in phase depending on the angle of incidence of the beams at the model and reference reflectors. These signals too have minimal amplitude and phase modulation resulting from imperfections of the optical source. Phase measurements are made between each signal and the electronic reference. The phase change vs angle change is about one percent between the two detected signals for either reflector. It is this difference that enables an absolute angle measurement to be made after the system is calibrated.

The phase measurement method for the four signals relative to the electronic reference are identical. One channel, the model visible, will be described with the difference between the others pointed out.

Referring to figures 4 and 5 the light signal, in this case the visible light from the He-Ne laser is detected by a silicon photodetector followed by an amplifier. The amplifier is an integral part of the detector, both contained

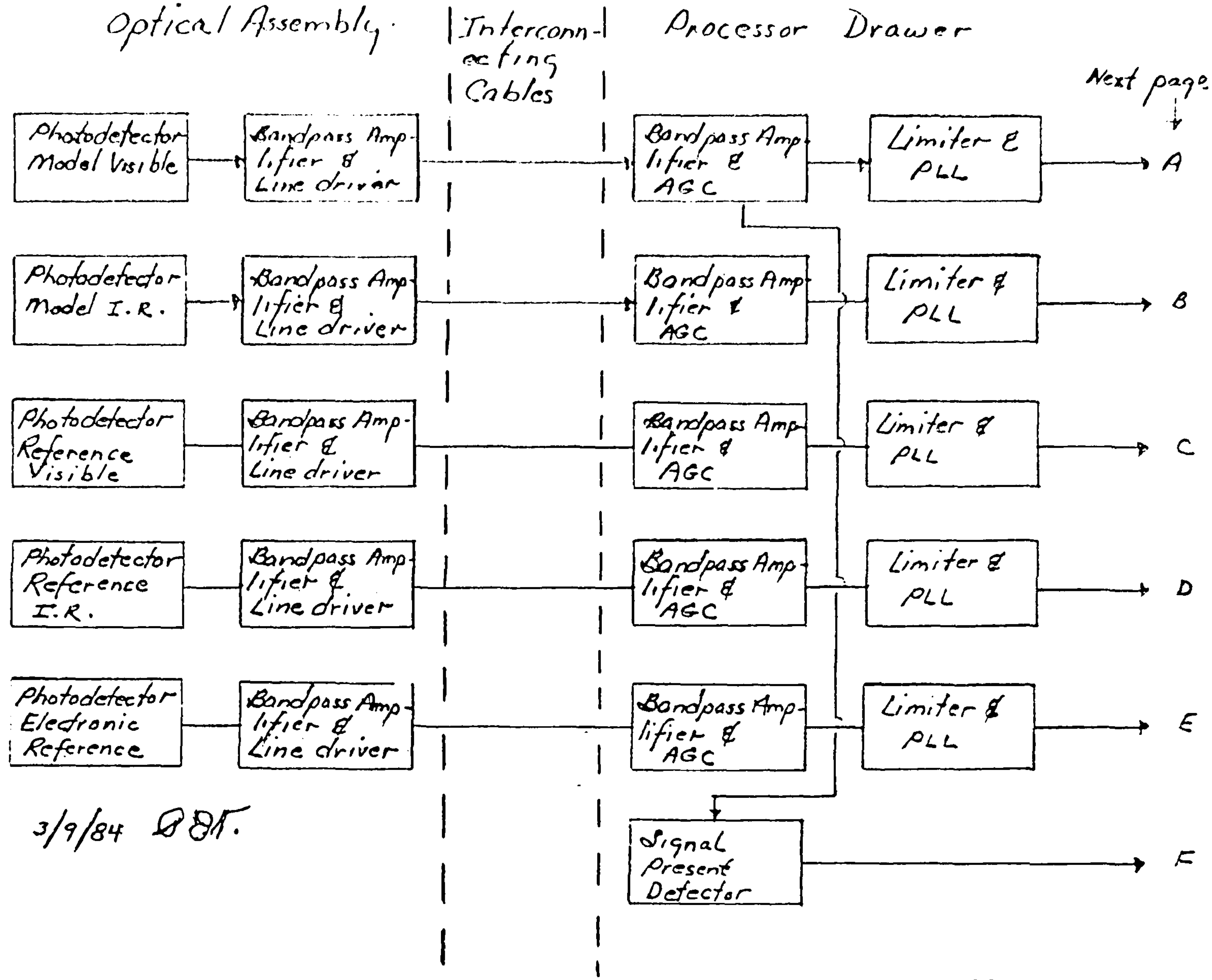


Figure 4: General Block Diagram of Electronics, 1 of 3

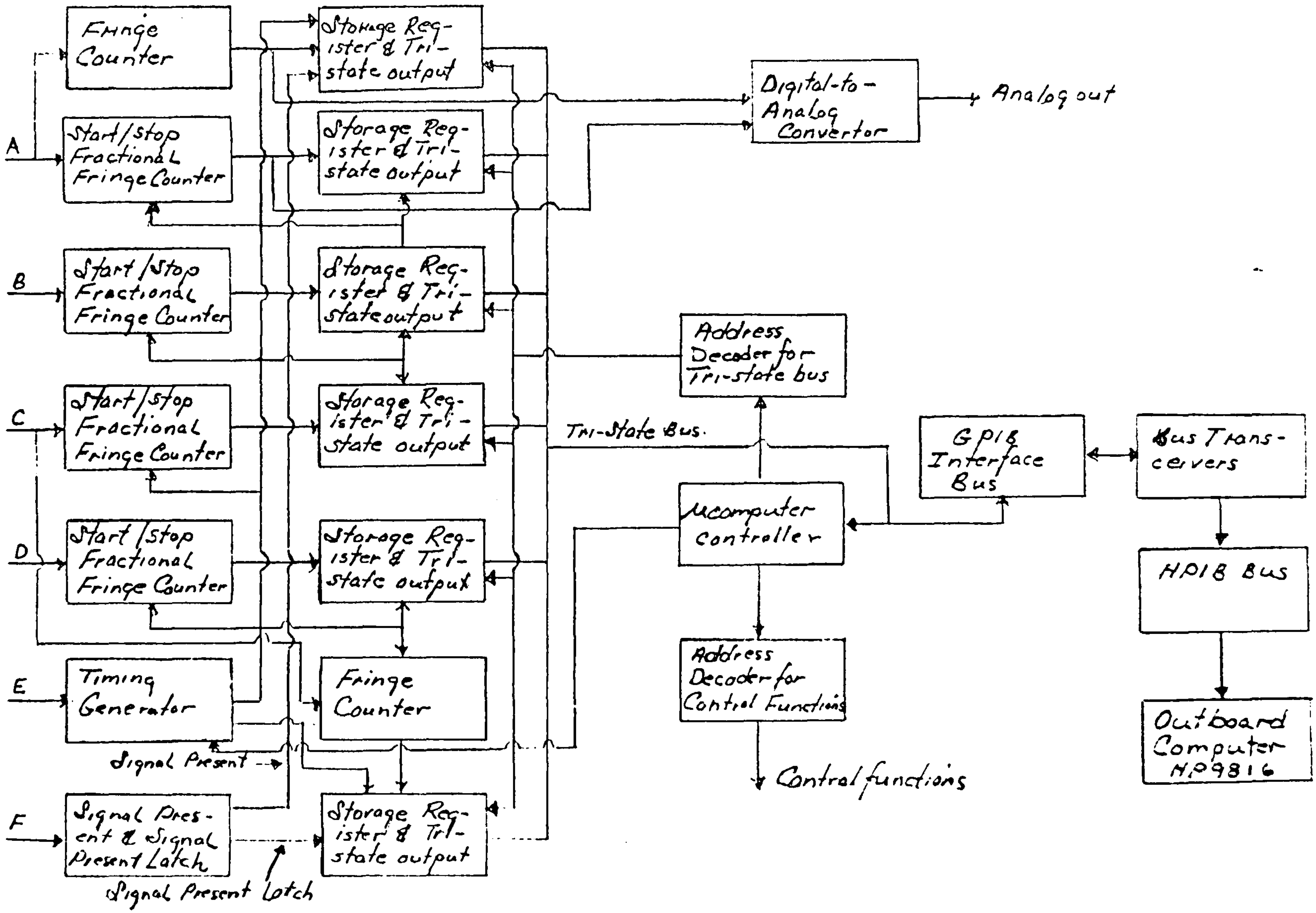


Figure 5: General Block Diagram of Electronics, 2 of 3

in a TO-5 package. The output from the detector amplifier is further amplified and band limited by an active bandpass filter and line driver. The output of the driver amplifier is transformer coupled. Interconnecting cables using twisted pair shielded wire connects the output of the detector box in the optical assembly to the processor drawer. The input at the processor is also transformer coupled. Transformers and twisted shielded pairs were used to minimize pick-up and eliminate ground loops. Signal magnitude was also intentionally kept at a low level up through the processor to minimize pick-up. The bandwidth up through the Phase Lock Loop (PLL), filter was intentionally made broad to minimize the effects of phase shifts associated with narrow bandwidths.

At the processor the signal is applied to a bandpass amplifier followed by an automatic gain control (AGC), circuit. The automatic gain control circuit has a useable dynamic range of 50 db. AGC starts for an input of 25 millivolts peak-to-peak maintaining the output at 1.4 volts peak-to-peak. The circuit has an attack time of 1 to 2 milliseconds and a decay time of 0.4 sec. AGC is necessary to maintain a relatively constant input to the limiter stage before the PLL.

Only the model visible channel has a signal present detector which consists of a full wave envelope detector and schmitt trigger with adjustable threshold. The attack and decay time is determined by the time constant of the envelope detector. An operational limiter amplifier follows the AGC circuit to limit the instantaneous amplitude of the signal before application to the PLL circuit.

The PLL is used as a filter and equivalent zero crossing detector. In other words, the nominal 2700 Hz sinusoidal input is converted to a digital output before application to the start/stop counter phase detector. Note that all channels so far, except for the signal present circuit for the model, are identical. This includes the electronic reference channel. The signal at A through E of figures 4 and 5 are now digital signals with nominal frequencies of 2700 Hz.

The basic principle of a start/stop phase detector is as follows. The electrical phase difference between two sinusoidal waveforms is determined by measuring the time between zero crossing of the two waveforms for a given slope. To measure the time a counter counting at a clock rate as determined by the resolution required by the phase measurement is gated. A typical counter sequence would be as follows. The counter output is reset to zero. The selected zero crossing and slope of the reference waveform enables the clock input to the counter and the same slope and zero crossing of the other waveform, the signal, disables the clock input to the counter. Since the clock rate and the period of the reference is known the counter output is a measure of the phase between the two waveforms. The ratio of the counter output to the number of counts for one complete cycle of phase difference is a fractional measure of the phase difference.

The nominal frequency of the electronic reference is 2700 Hz. The requirement for absolute angle measurement dictated a clock rate of 2.7 MHz, one thousand times the frequency of the electronic reference. Two cycles of the electronic reference were used to make a phase measurement. The time during the second half of the second cycle is used to read the contents of

the counter and reset the counter for the next measurement cycle. All the timing is derived from the electronic reference and all four phase measurements correspond to a given two cycles of reference. The absolute angles for the model and reference reflectors are derived from the outputs of the start/stop fractional fringe counters. Because the fringe angles per cycle of phase are different for the visible and model by approximately one percent, a unique relationship exists between the two counters as a function of model angle. The same is true for the reference channel. From this unique relationship the system can be calibrated as an absolute angle measuring device.

Note that all outputs from the fractional fringe counters are accurate fractional fringe measurements which repeat for each fringe angle change of model or reference angle. A relative angle measurement is made by bidirectionally counting the whole fringe cycles. The fringe counter circuit also consists of a fractional fringe counter using a binary-code-decimal counter. Each fractional fringe count measurement is compared to the previous measurement to determine if whole fringe boundaries have been crossed. The decision logic compares the present measurement to the previous measurement in the following manner. If the previous counter output is between 700 and 999 and the preset counter output is between 000 and 399 the fringe counter is incremented by one. If the previous counter output is between 000 and 399, and the present counter output is between 700 and 999, the fringe counter is decremented by one. Exact angle measurement requires that the fringe counter be reset at some known model reference angle initially. The absolute angle measurement does not require initialization at an exact model or reference angle. (Initially the system was intended as a

full time absolute angle measurement system, but data transfer and computation time of the outboard computer limited its usefullness to low angle rates). Because the fractional fringe count is always absolute and the fringe count method has very high noise immunity due to the large decision window, the absolute measurement is used to update the fringe counter when necessary. The fringe counter output plus fractional fringe counter output, with appropriate conversion factors, is the relative angle measurement. The above description of the fringe counter also applies to the reference fringe counter.

The microcomputer controls the activity of the GPIB interface, directs control functions from the outboard computer to the function to be controlled, and addresses the storage registers for sequential transfer of the data through the GPIB. The shift registers are updated every two cycles of the electronic reference. During the last half of the second cycle a data valid flag is sent to the microcomputer. During this time the microcomputer can request a data transfer if it has received a data request from the outboard computer. Data transfer is initiated and the rate of data transfer is determined by the outboard computer. Data in the storage registers is not updated until transfer of the complete data set is completed.

The Bus Transceivers provide the interface to the standard HP1B bus to the outboard computer.

Figure 6 is a general block diagram of the electronics in the optical assembly and the external interface. The photodetectors have already been described. The electronic reference circuitry differs from the other four in

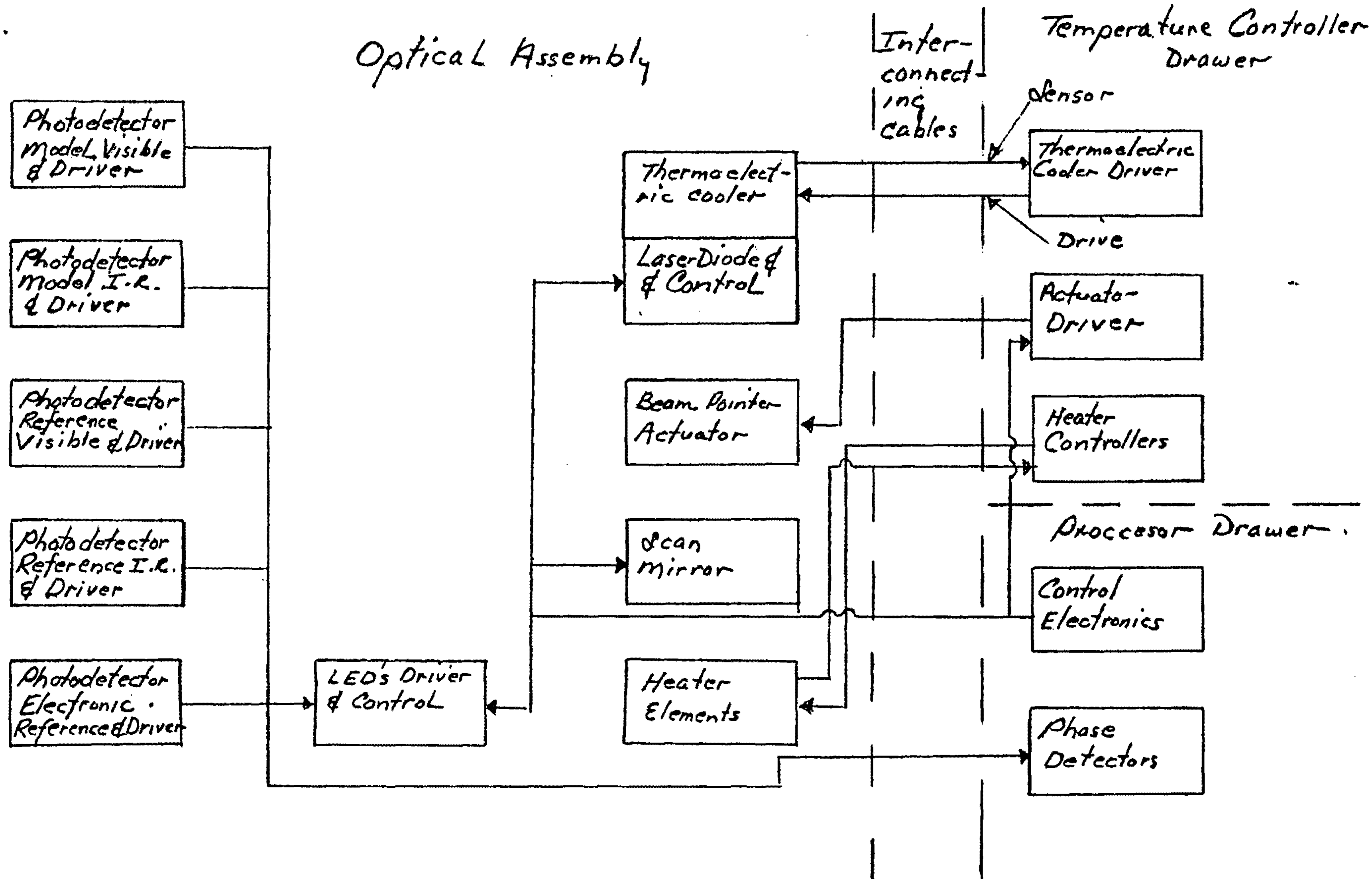


Figure 6: General Block Diagram of Electronics, 3 of 3

bandwidth, and the output also drives the light emitting diodes, LED's, driver and control circuitry. Each signal detector housing has an LED, the light from which can be seen by the respective photodetector. The outboard computer can turn the LED's on and off. The signal from the electronic reference is used to modulate the LED's light output. The purpose of this circuit is to simulate a controlled modulated light source from which drift in the electronics can be corrected out. During the calibration process, a phase measurement is made with the LED's. At subsequent times measurements are again made and any differences are corrected out in the angle computations.

A laser diode is used as a light source in the system. The laser diode is driven from a circuit which maintains the output light level at a constant level. A photodiode in the same package as the laser diode is used as a feedback element to maintain the output light power current. Such a circuit is necessary because the lifetime of the laser diode is very sensitive to output light power. The output light wavelength of the laser diode is also strongly dependent on temperature (.25 nm/^{o}C). To control the temperature of the laser diode, it is mounted on a thermal sink to which a thermoelectric heater/cooler is attached. The thermoelectric heater/cooler drive electronics is located in the temperature controller drawer. A thermistor feedback element is mounted on the heat sink to sense the temperature of the laser diode.

Tape-on film heater elements are mounted within the upper and lower sections of the optical assembly for ambient temperature control. A separate controller is used for each section with temperature sensing accomplished in

each section by RTD's. The temperatures are adjusted at the respective controllers.

All of the beam pointer actuator driver and control electronics is in the controller Drawer. The actuator can be controlled manually or by the outboard computer. Limit switches are used to ensure that motor turn off occurs at the extreme ends of travel. The scan mirror consists of a single phase a. c. motor driving a cam. The scanning mirror is controlled by the outboard computer.

Output data sequence

Data: Binary consisting of two bytes/word and 8 bits/byte. The sequence of 12 bytes is referred to as a data block. The data sequence/byte is as follows:

1. MSByte of relative integral fringe counts for model visible, 00H or 01H; 00H=signal present for data block, 01H=signal not present for data block.
2. LSByte of relative integral fringe counts for model visible; relative integral fringe counts resetable to 78H (120d).
3. MSByte of relative integral fringe counts for reference visible, 00H.
4. LSByte of relative integral fringe counts for reference visible; MSBit=signal present Lost, resetable to 0 from computer only during signal present; 7 LSBits are the relative integral fringe counts resetable to 14H (20d).
5. MSByte of fractional fringe counts for model visible, 4 MSBits = 0H.

6. LSByte of fractional fringe counts for model visible.

7. MSByte of fractional fringe counts for model i.r., 4 MSBits=0H.

8. LSByte of fractional fringe counts for modeli.r.

9. MSByte of fractional fringe counts for reference visible, 4 MSBits=0H.

10. LSByte of fractional fringe counts for reference visible.

11. MSByte of fractional fringe counts for reference i.r., 4 MSBits=0H.

12. LSByte of fractional fringe counts for reference i.r.

Phase-Lock-Loop Adjustment Procedure

To adjust the phase the phase-lock-loops (PLL), display the output of the respective J-N, N = Number, BNC connector and square wave at the point on the card as defined below on a two beam scope. Trigger the scope from the square wave and adjust the variable resistor as specified below for a well defined phase lock. Remove the input signal and make sure that the PLL locks up again when signal is reapplied. Readjust as necessary to assure a solid lock and reacquisition.

J-10 I. R. Reference-Card #4

Adjust R-9

Monitor square wave at 28 12.

J-11 Visible Reference-Card #4

Adjust R-5

Monitor square wave at 1 12

J-9 I. R.Signal-Card #3

Adjust R-5

Monitor square wave at 1 12

J-8 Visble Signal-Card #3

Adjust R-9

Monitor square wave at 28 12.

J-12 Electronic Reference - Card #9

Adjust R-5

Monitor square wave 1 5.

Computer Control Commands

1. Reset of model relative integral fringe counter: Reset=CHR$(02); Enable=CHR$(00). Reset value = 78H (120d).
2. Reset of reference relative integral fringe counter: Reset=CHR$(03); Enable=CHR$(00). Reset value =14H(20d).
3. Reset of analog: Reset=CHR$(04); Enable=CHR$(00).
4. Reset of 1, 2, & 3: Reset= CHR$(05); Enable=CHR$(00).
5. Reset of signal present latch: Reset=CHR$(06); Enable=CHR$(00).
6. Actuator forward: Forward=CHR$(07); Stop=CHR$(00). Actuator moves in.
7. Actuator aft: Aft=CHR$(08); Stop=CHR$(00). Actuator moves out.
8. Drift correction, LED's on and Laser-diode off: On=CHR$(09); Off=CHR$(00).
9. Mirror scan: Enable=CHR$(10); Disable=CHR$(00).
10. Reset angle sensor microcomputer and interface: Send IFC over HBIB interface.
11. Command terminator, *, CHR$(42).

    I/O statements for commands

    Output @ HP1B using "#,K"; CHR$(X), CHR$(00),...., CHR$(42)

    Interface Clear, IFC

        Write IO 7, 23; 143

        Write IO 7, 23; 15

VI. ELECTRICAL SCHEMATICS

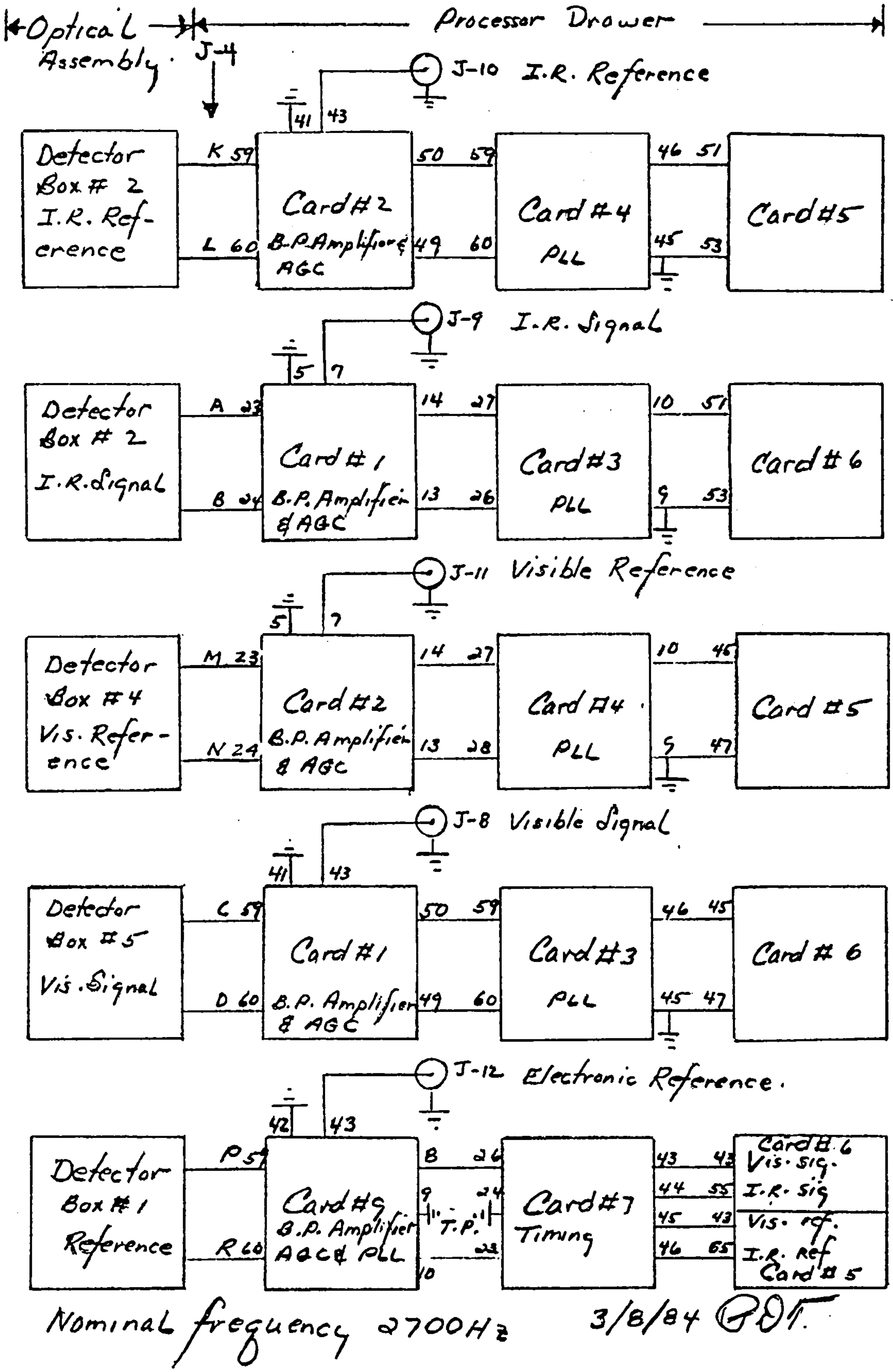


Figure 7: Flow Diagram of the Detected Optical Signals

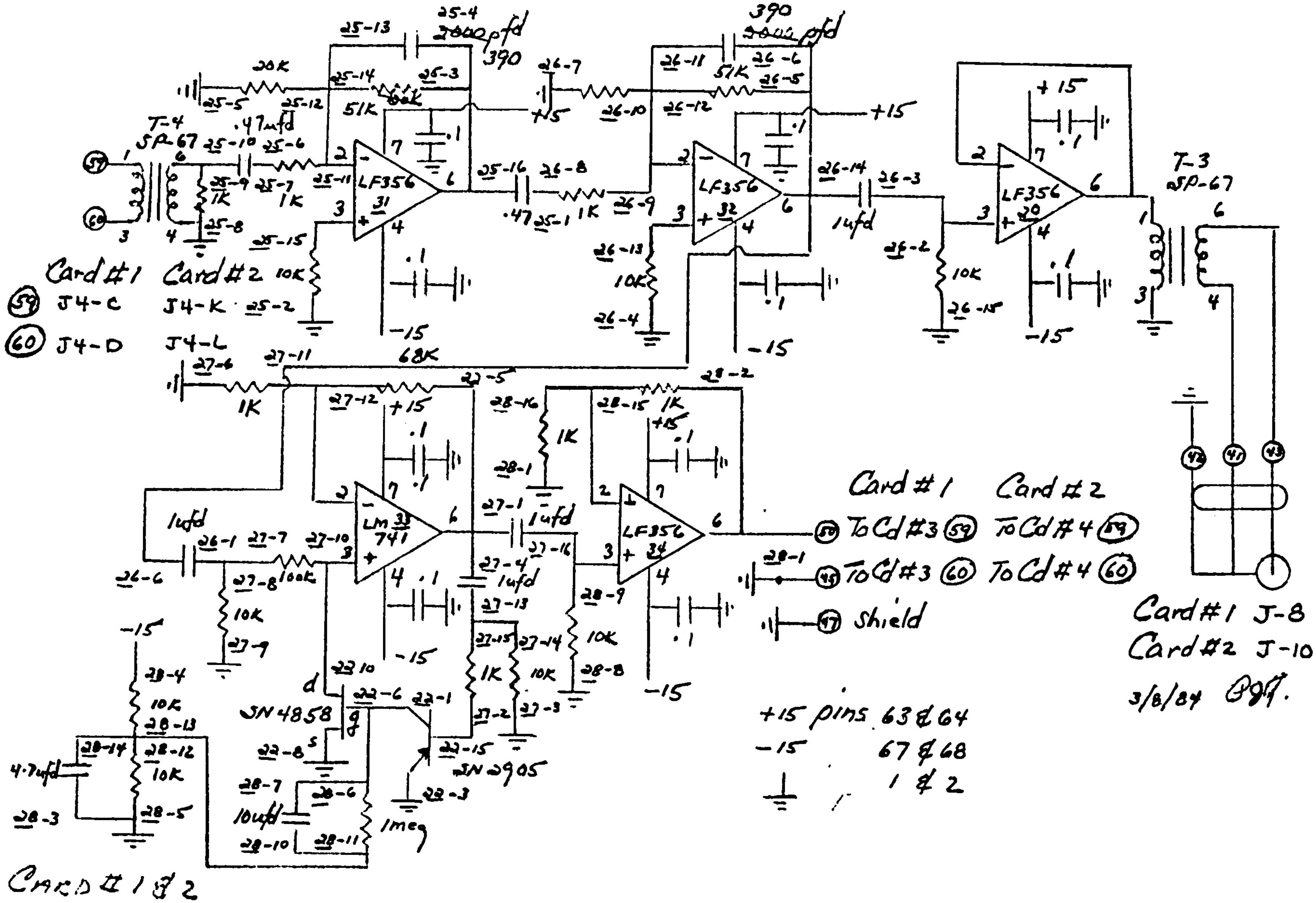


Figure 8: Bandpass Amplifier and AGC, Card 1 and 2

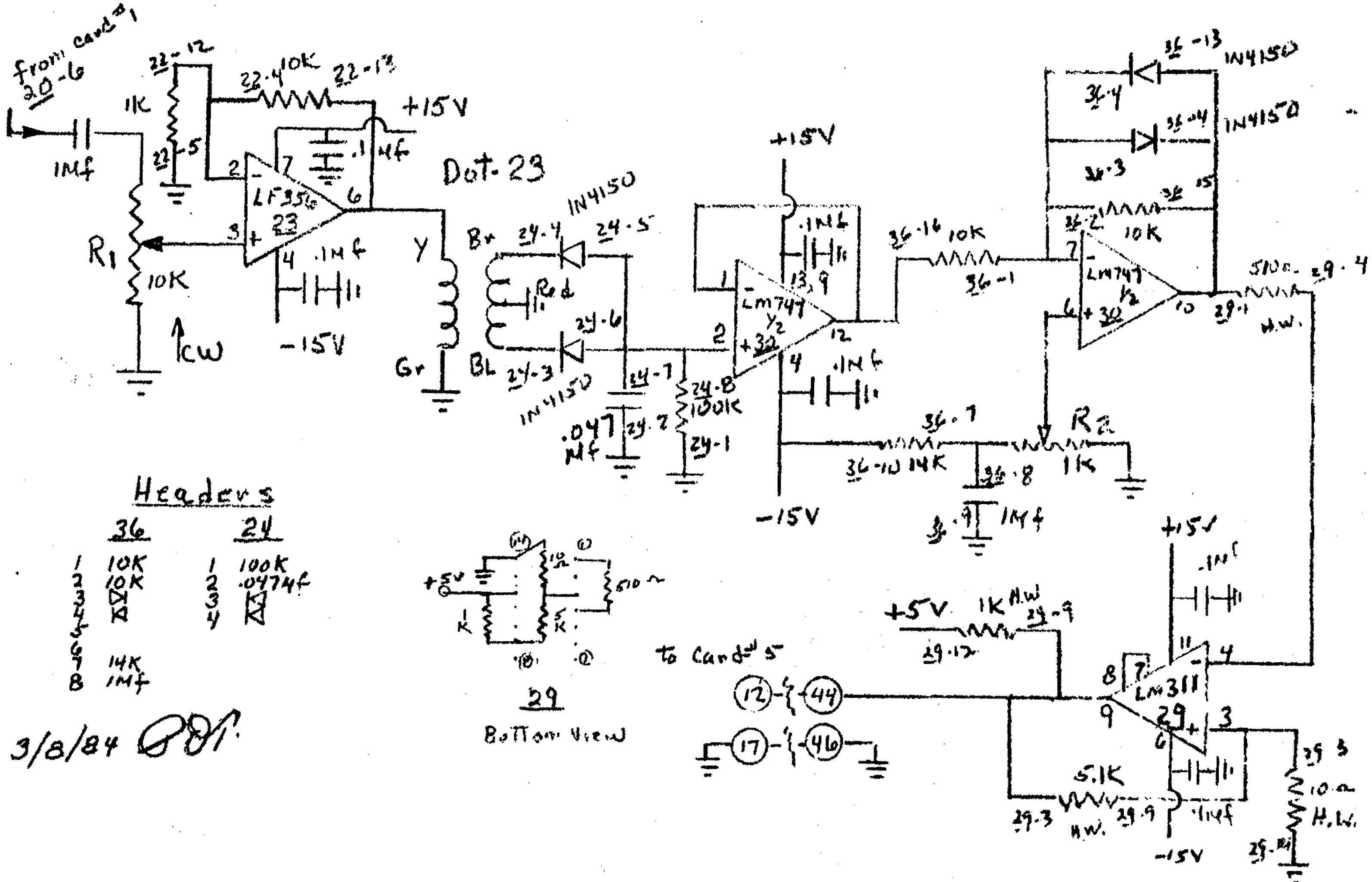
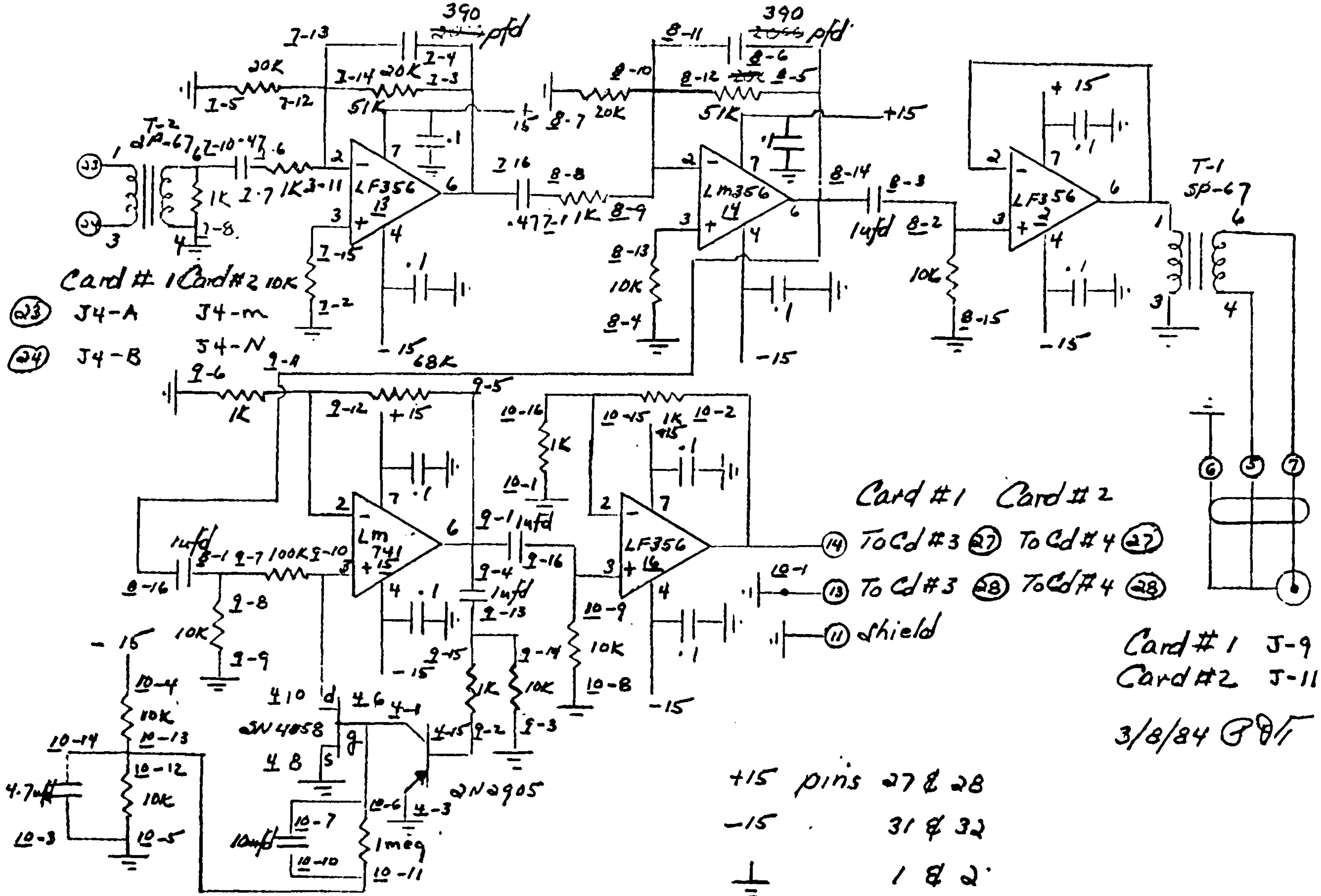


Figure 9: Model Visible Signal Presence, Card 1

 (See Addendum Page 164)



CARD #1 & 2

Figure 10: Bandpass Amplifier and AGC, Card 1 and 2

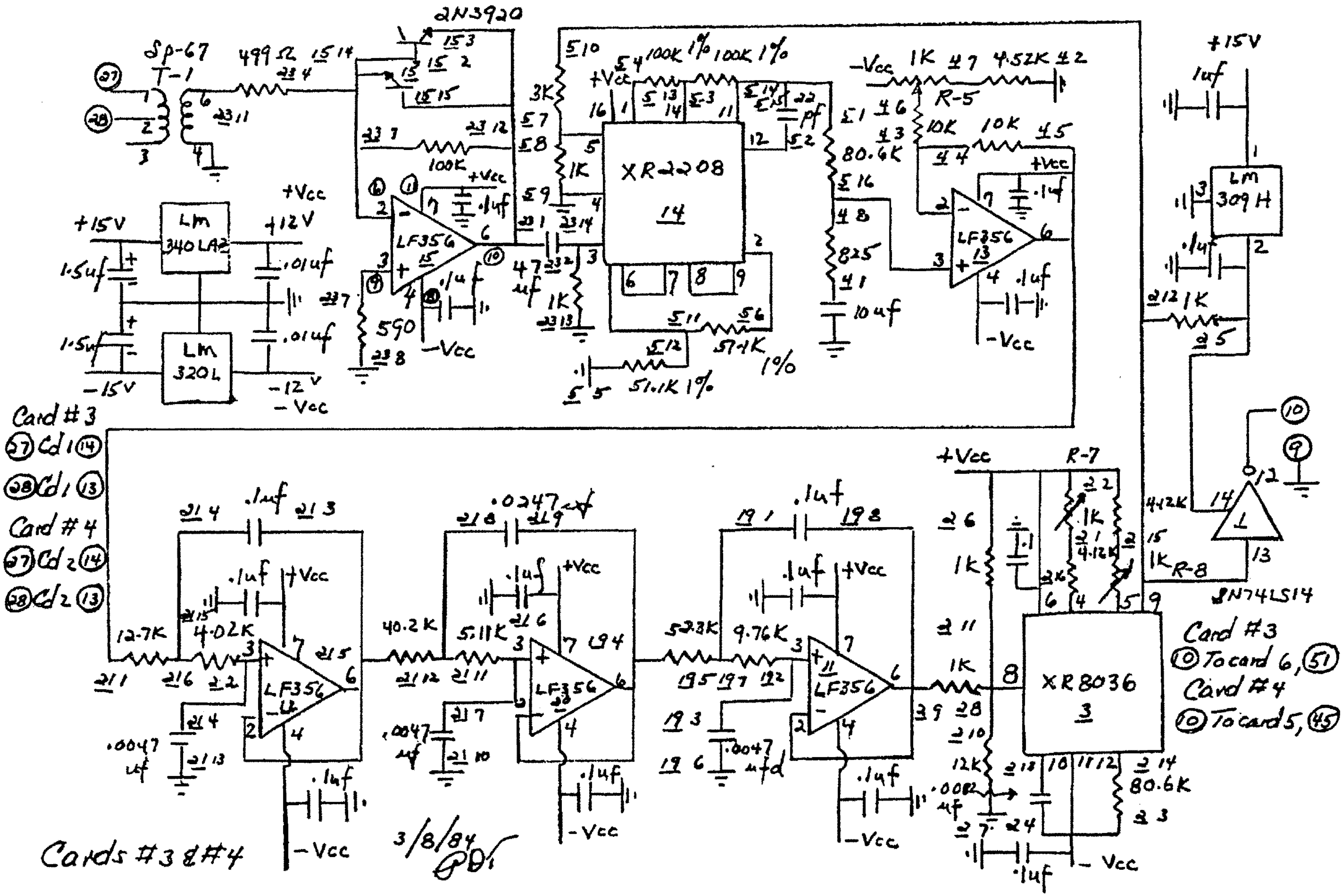


Figure 11: Limiter and PLL, Card 3 and 4

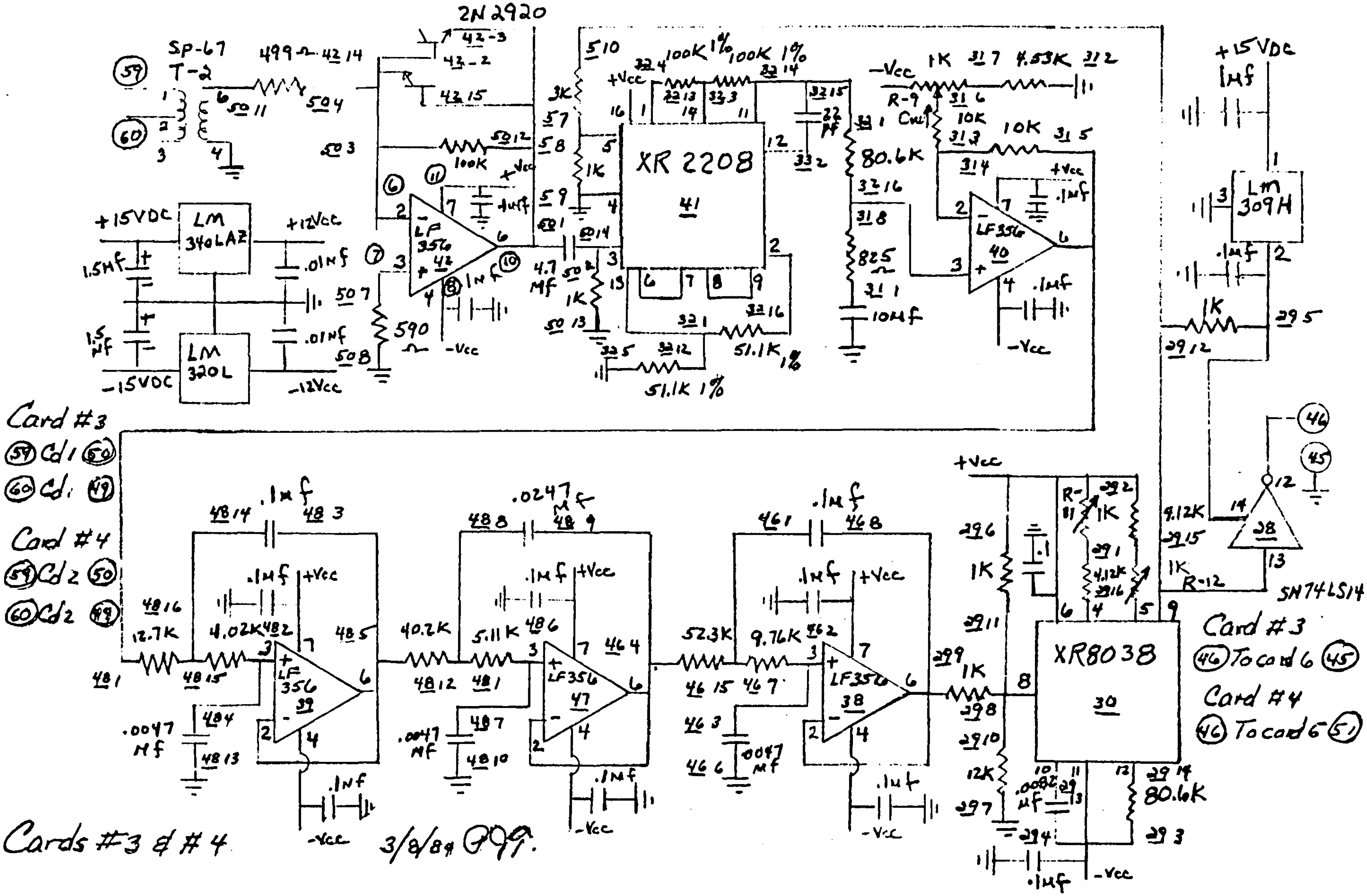


Figure 12: Limiter and PLL, Card 3 and 4

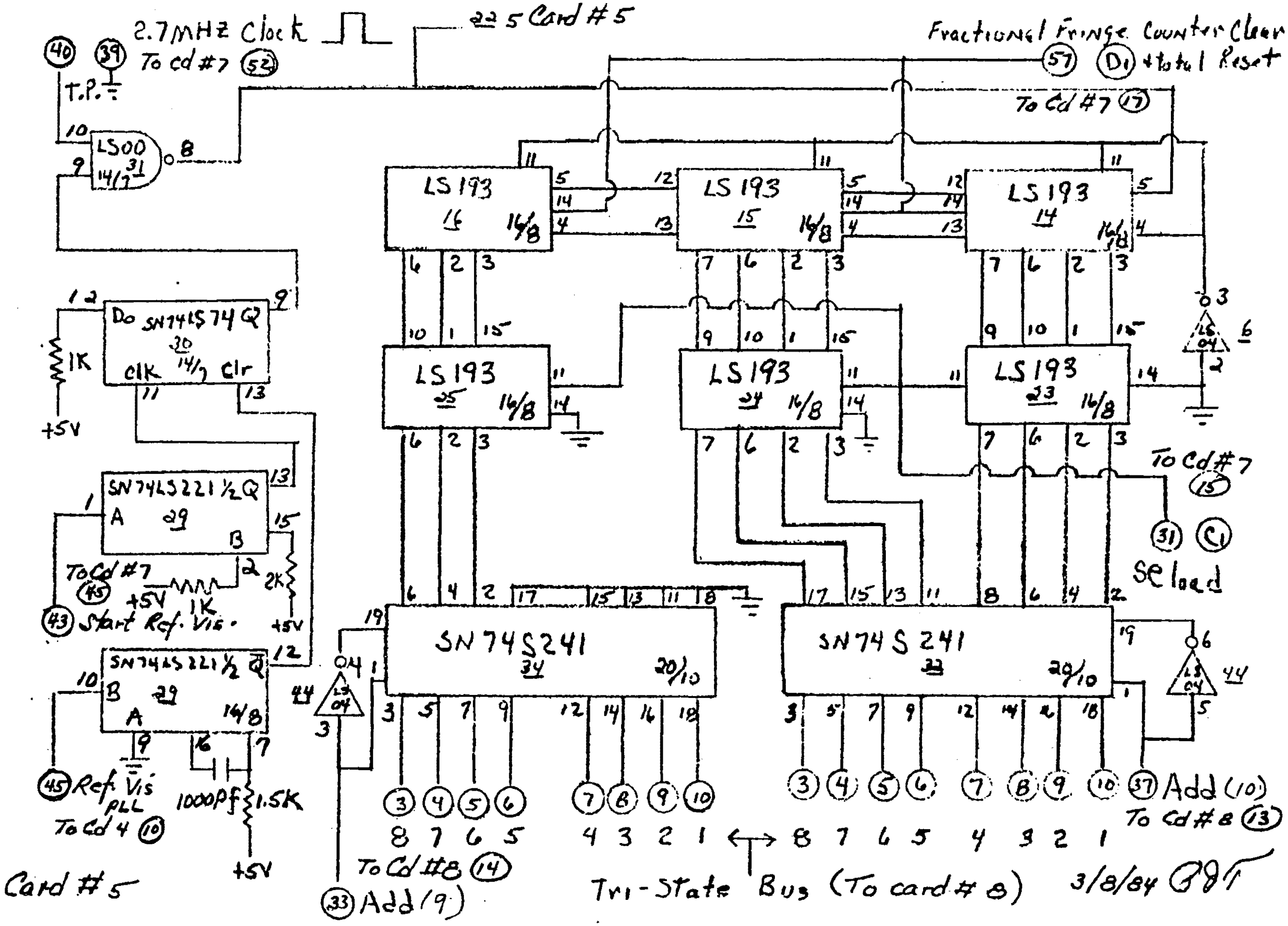


Figure 13: Reference Visible Phase Detector, Card 5

 (See Addendum Page 166)

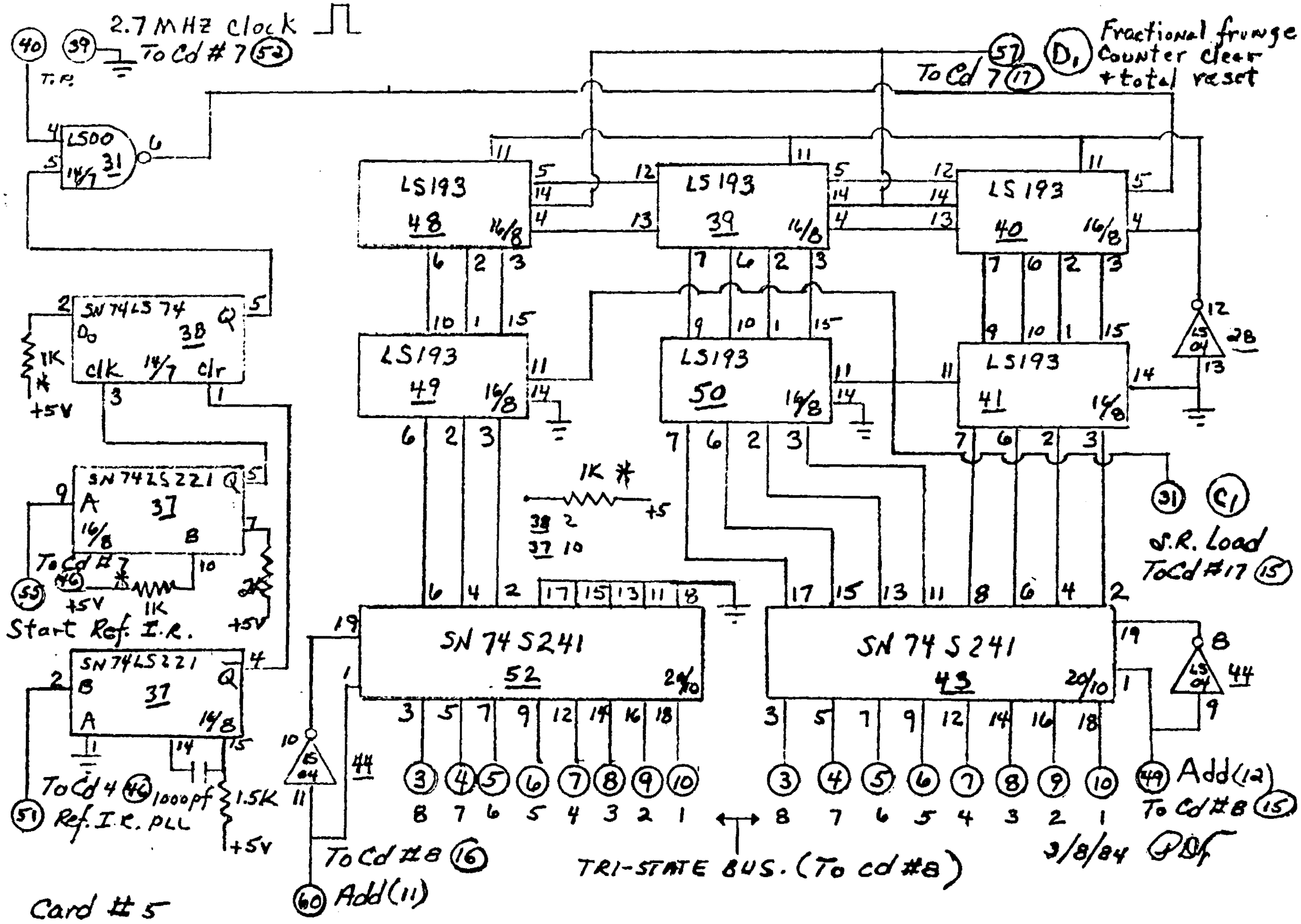


Figure 14: Reference I.R. Phase Detector, Card 5

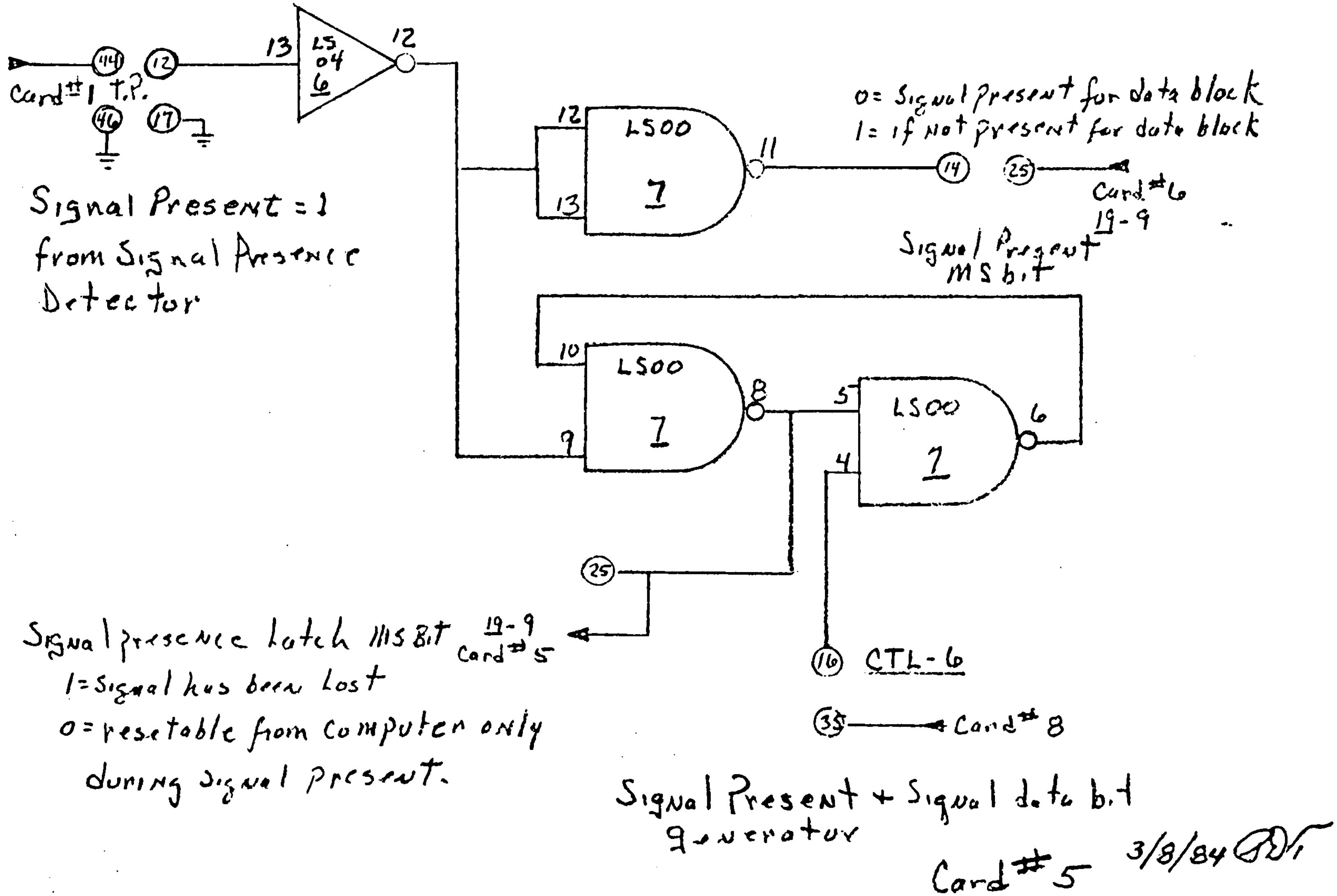


Figure 15: Signal Present and Signal Present Latch, Card 5

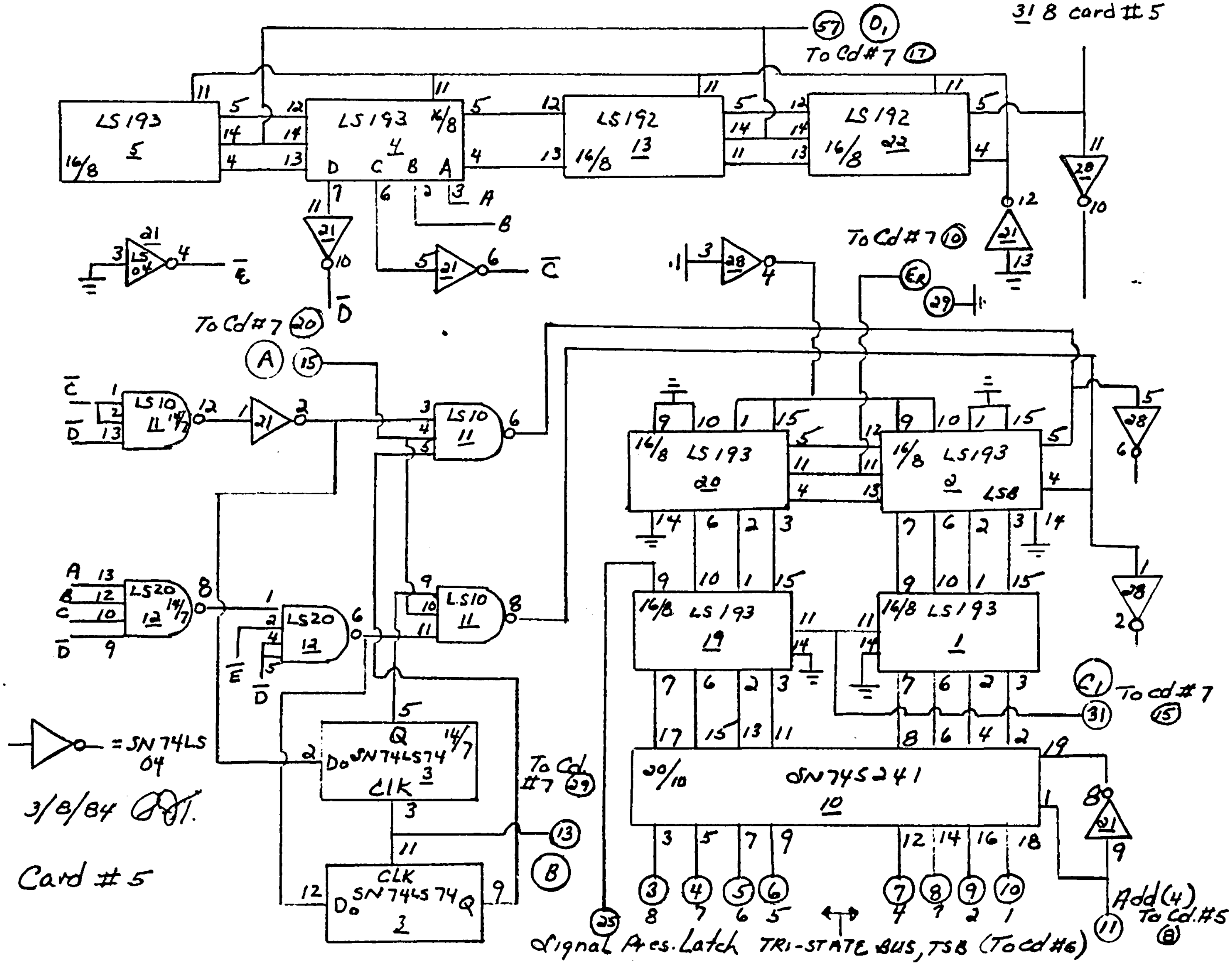


Figure 16: Reference Fringe Counter, Card 5

 (See Addendum Page 166)

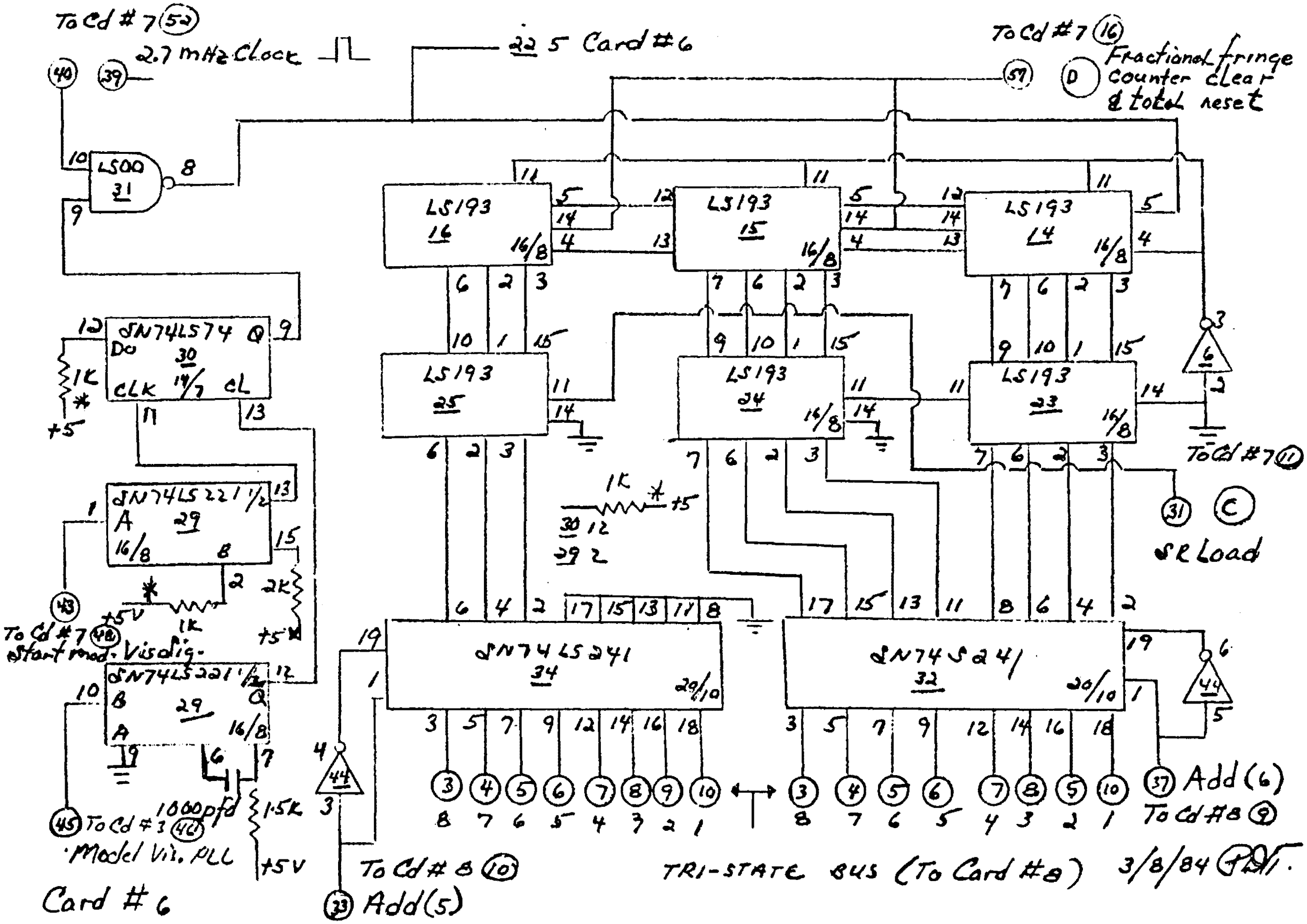


Figure 17: Model Visible Phase Detector, Card 6

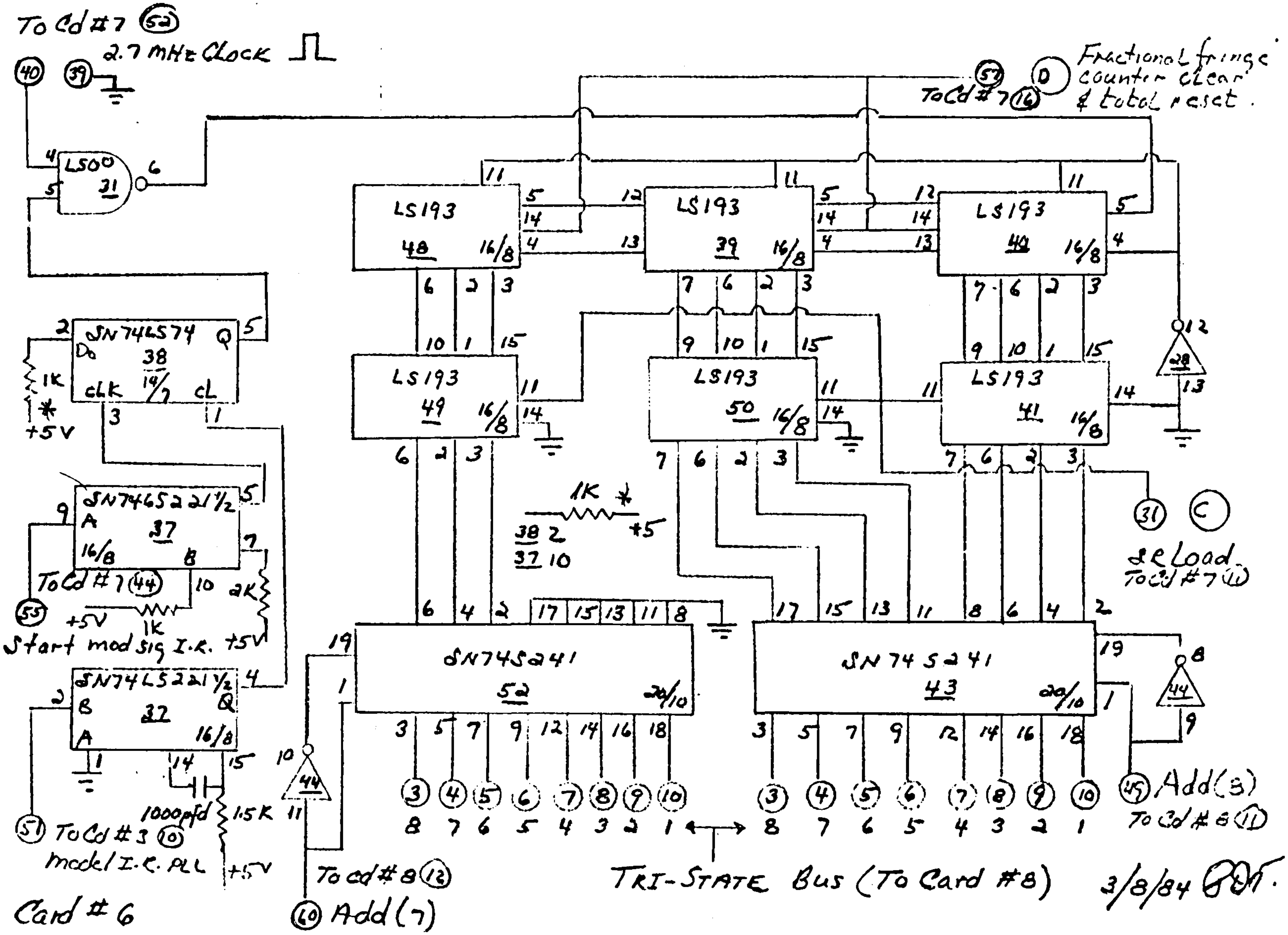


Figure 18: Model I.R. Phase Detector, Card 6

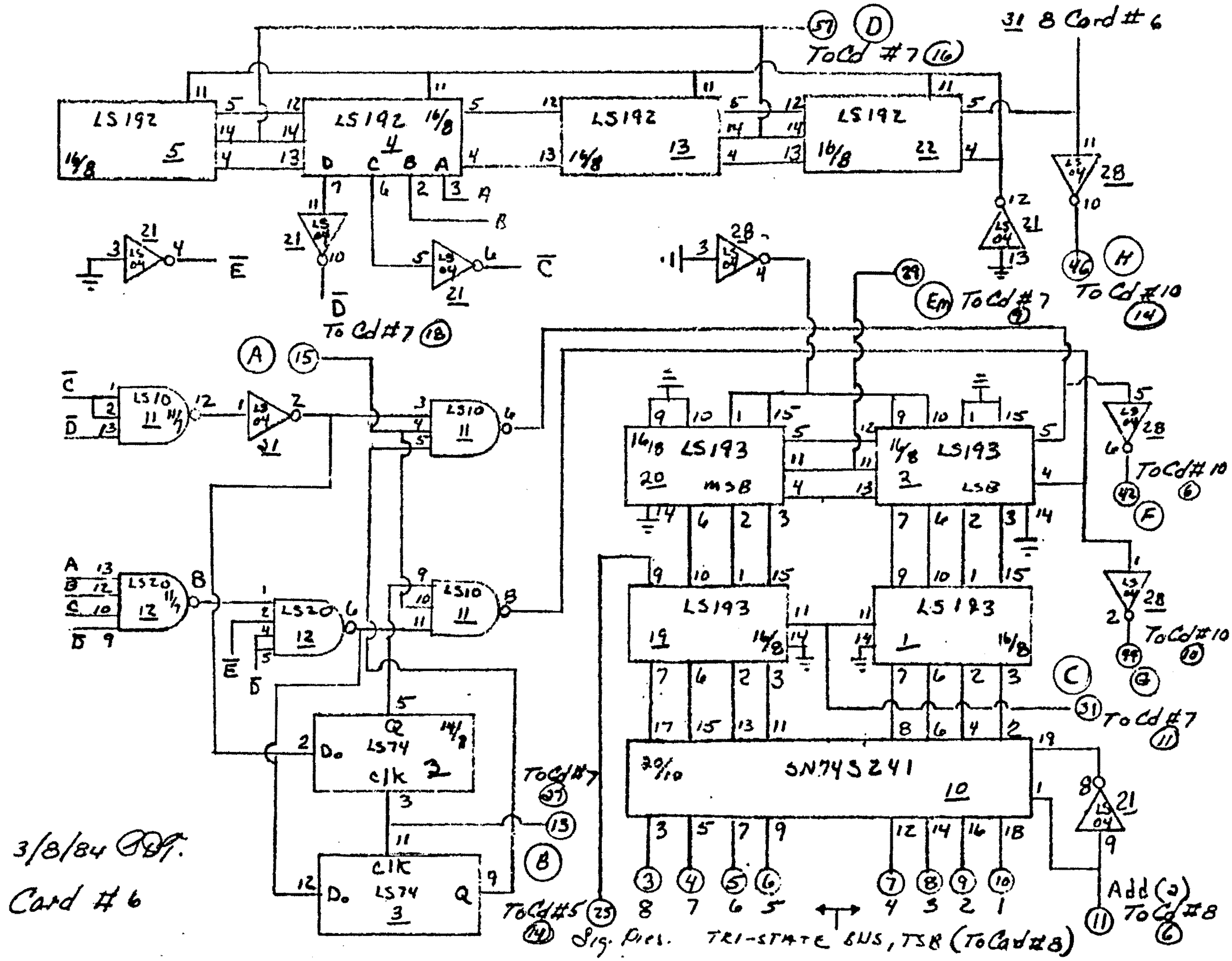


Figure 19: Model Fringe Counter, Card 6

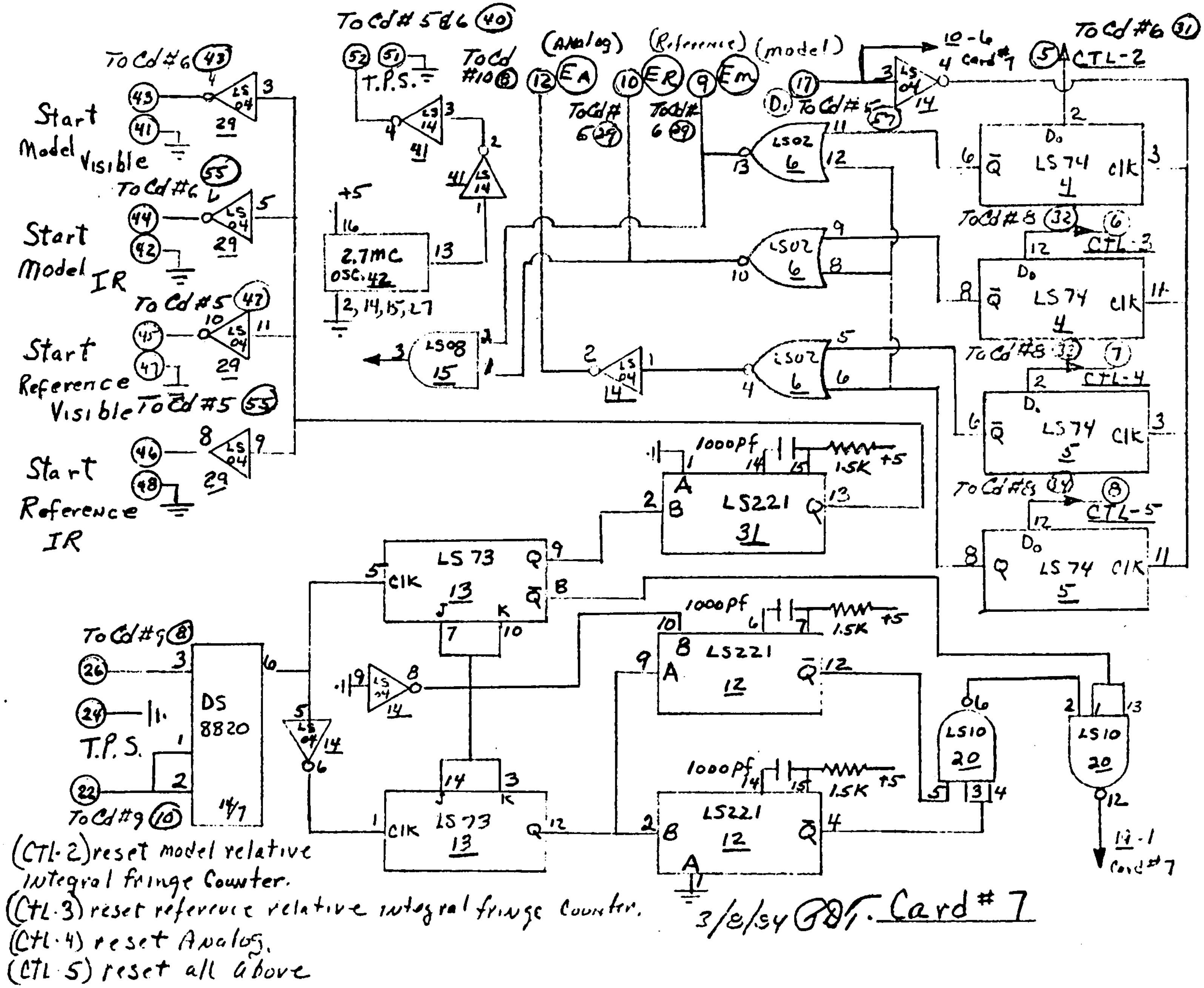


Figure 20: Timing Generator, 1 of 2, Card 7

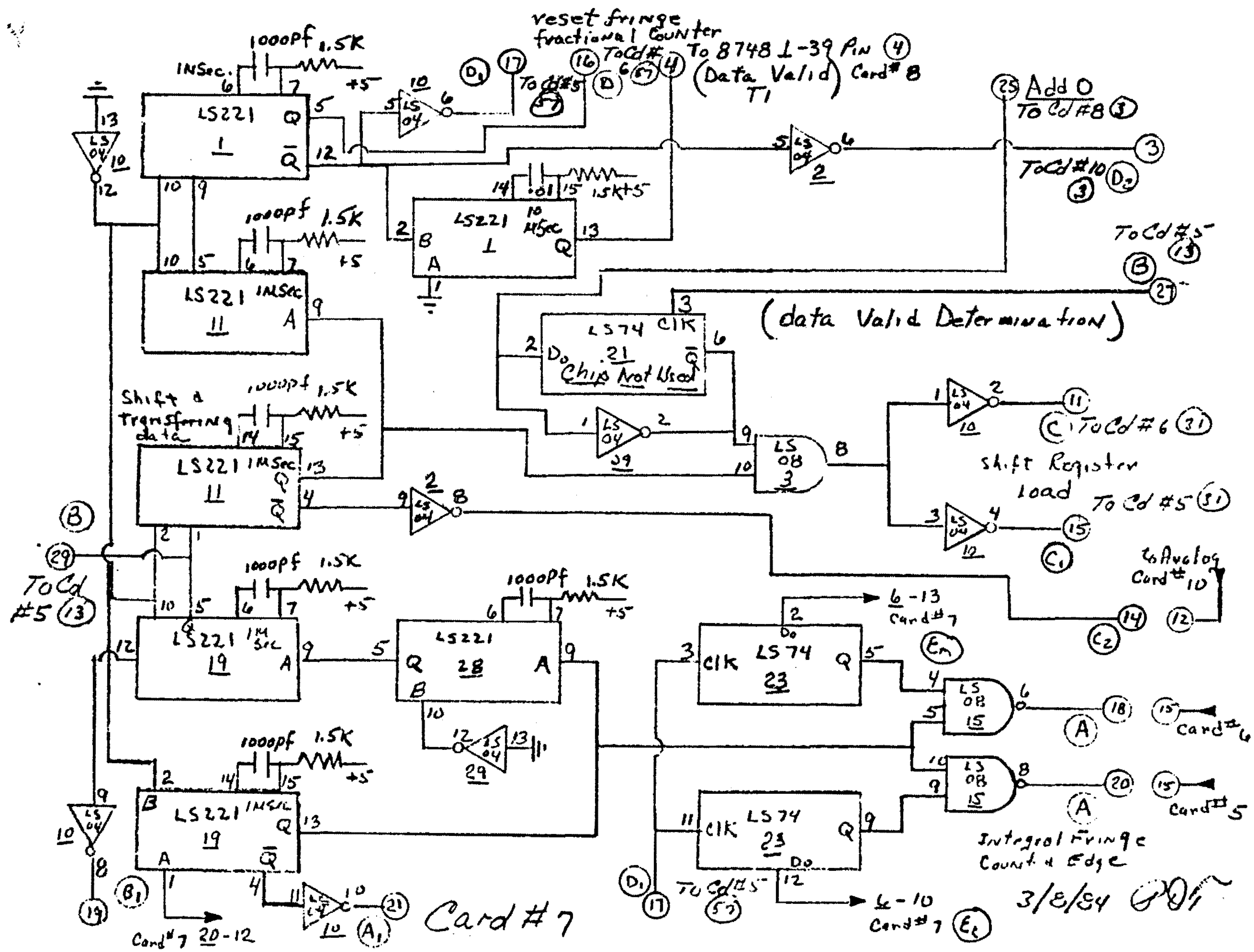


Figure 21: Timing Generator, 2 of 2, Card 7

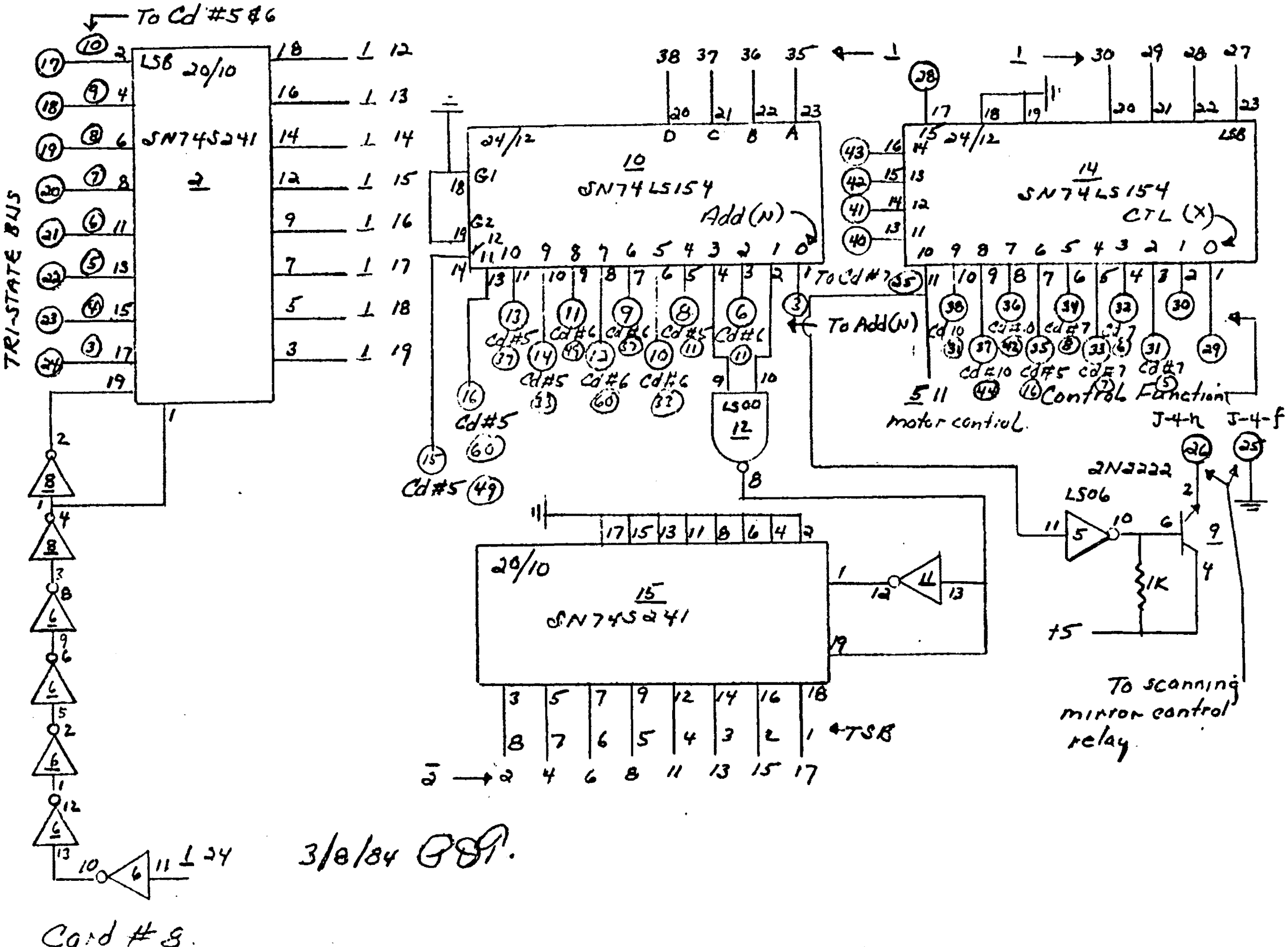


Figure 22: Address and Control Decoders, Card 8

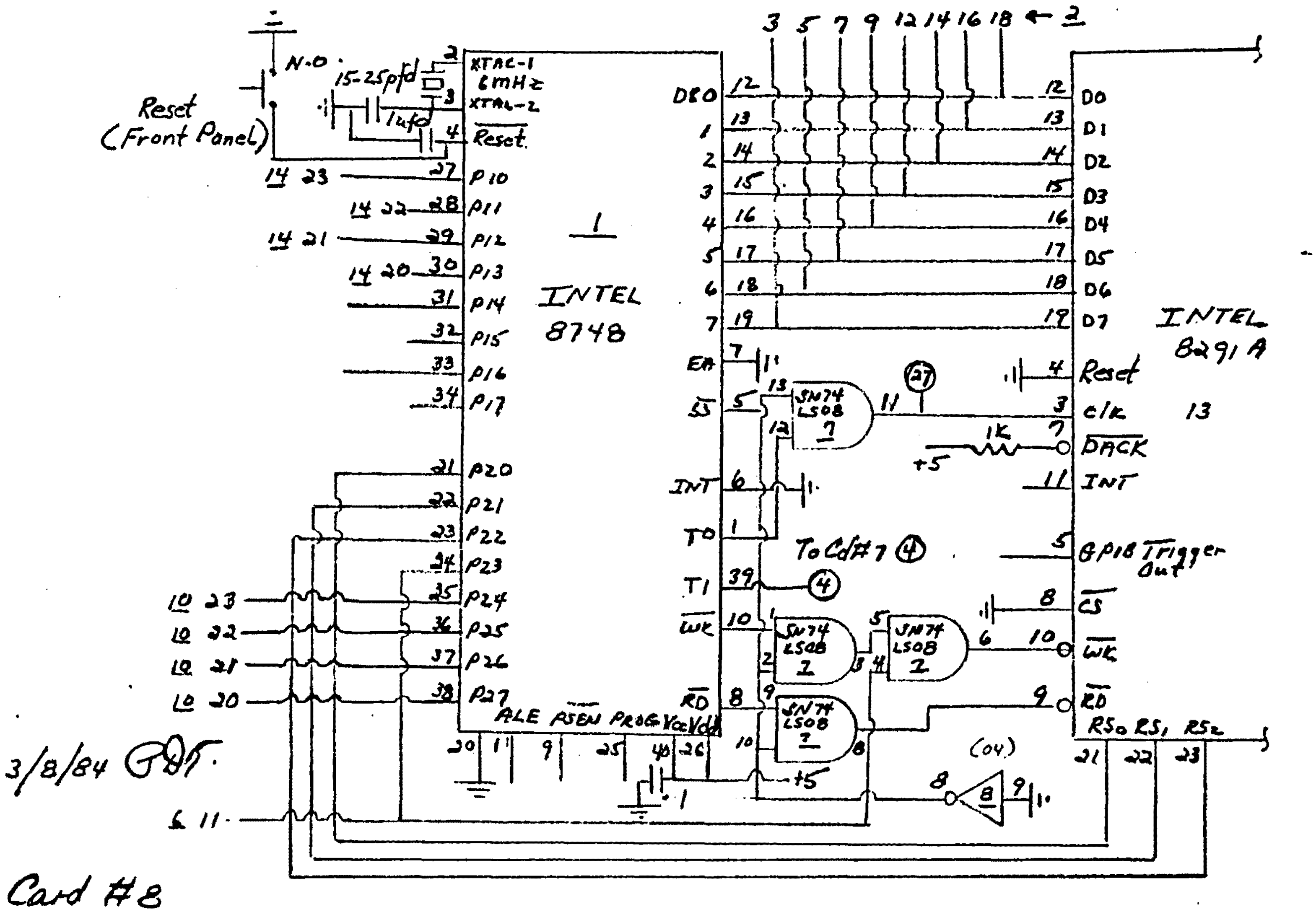


Figure 23: Microcomputer and GPIB, Card 8

8748 Code					PL = Program Line				
PL	Hex Code	PL	Hex Code	PL	Hex Code	PL	Hex Code	PL	Hex Code
00	00	10	00	20	3A	30	23	40	0C
01	B8	11	90	21	23	31	2A	41	3A
02	00	12	23	22	22	32	90	42	30
03	14	13	0A	23	90	33	23	43	32
04	F0	14	3A	24	23	34	0d	44	50
05	75	15	23	25	0E	35	3A	45	52
06	23	16	00	26	3A	36	23	46	80
07	0d	17	90	27	23	37	E4	47	04
08	3A	18	23	28	09	38	90	48	42
09	23	19	0C	29	90	39	23	49	00
0A	02	1A	3A	2A	23	3A	0d	4A	00
0B	90	1B	23	2B	E0	3B	3A	4B	00
0C	23	1C	01	2C	90	3C	23	4C	00
0d	25	1D	90	2D	23	3D	00	4D	00
0E	3A	1E	23	2E	0F	3E	90	4E	00
0F	23	1F	0d	2F	3A	3F	23	4F	00

Figure 24: 8748 Code, 1 of 2

8748 Code (Continue) PL = Program Line									
PL	Hex Code	PL	Hex Code	PL	Hex Code	PL	Hex Code	PL	Hex Code
50	BF	60	47	70	EC	80	23	90	03
51	0C	61	3A	71	50	81	09	91	AE
52	B8	62	8A	72	BC	82	3A	92	C6
53	01	63	08	73	01	83	80	93	C0
54	00	64	3A	74	04	84	12	94	FD
55	46	65	F9	75	39	85	88	95	39
56	54	66	18	76	00	86	04	96	B9
57	23	67	EF	77	00	87	83	97	85
58	F9	68	57	78	00	88	92	98	00
59	3A	69	23	79	00	89	39	99	E9
5A	80	6A	09	7A	00	8A	23	9A	98
5B	32	6B	6B	7B	00	8B	08	9B	04
5C	5F	6C	EB	7C	00	8C	3A	9C	80
5d	04	6d	50	7d	00	8d	56	9D	00
5E	5A	6E	B8	7E	00	8E	AD	9E	00
5F	F8	6F	0A	7F	00	8F	97	9F	00
C0	BC	F0	23	F4	0A				
C1	87	F1	00	F5	BC				
C2	04	F2	39	F6	01				
C3	96	F3	B8	F7	83				

Figure 25: 8748 Code, 2 of 2

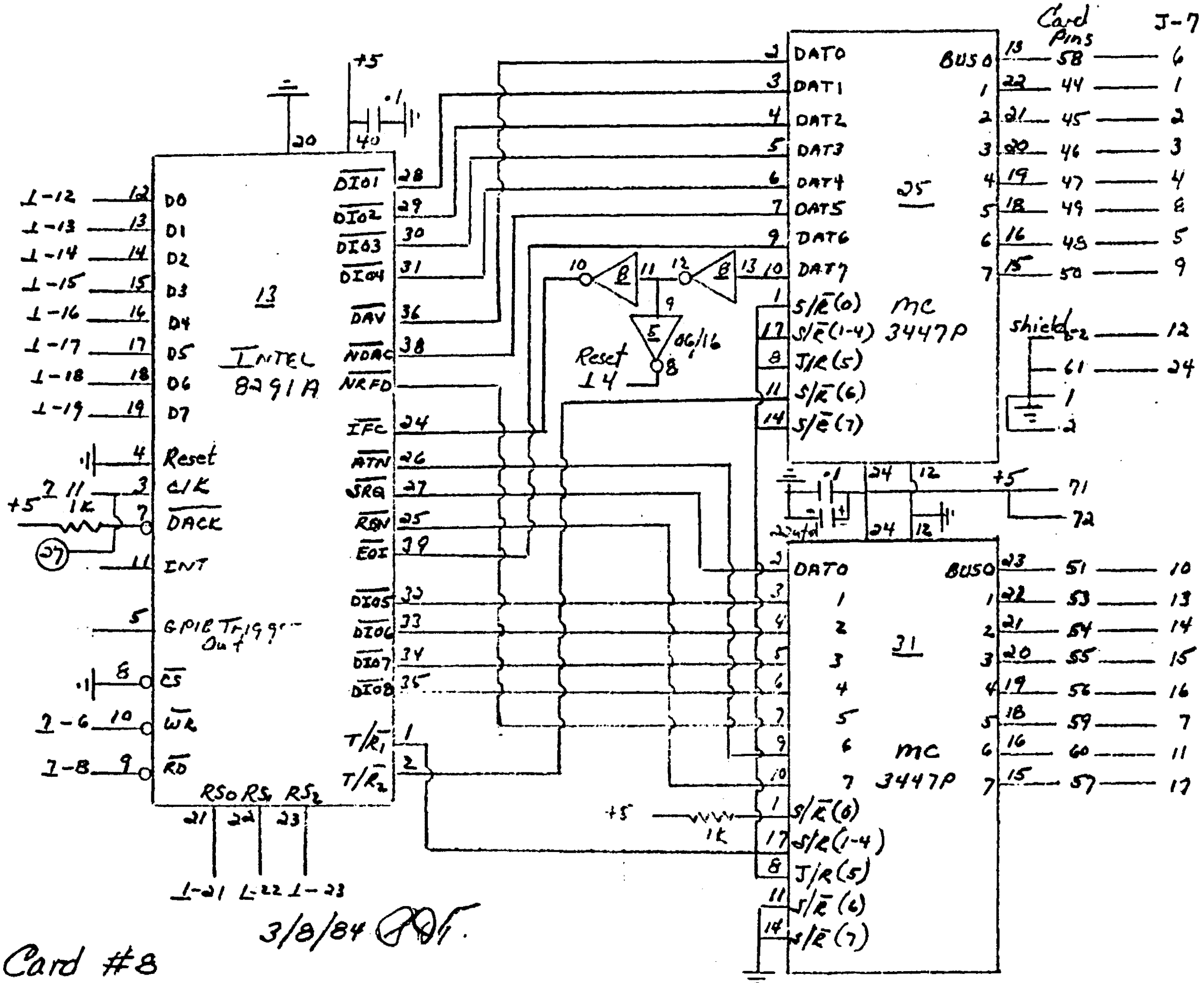


Figure 26: GPIB and Bus Interface, Card 8

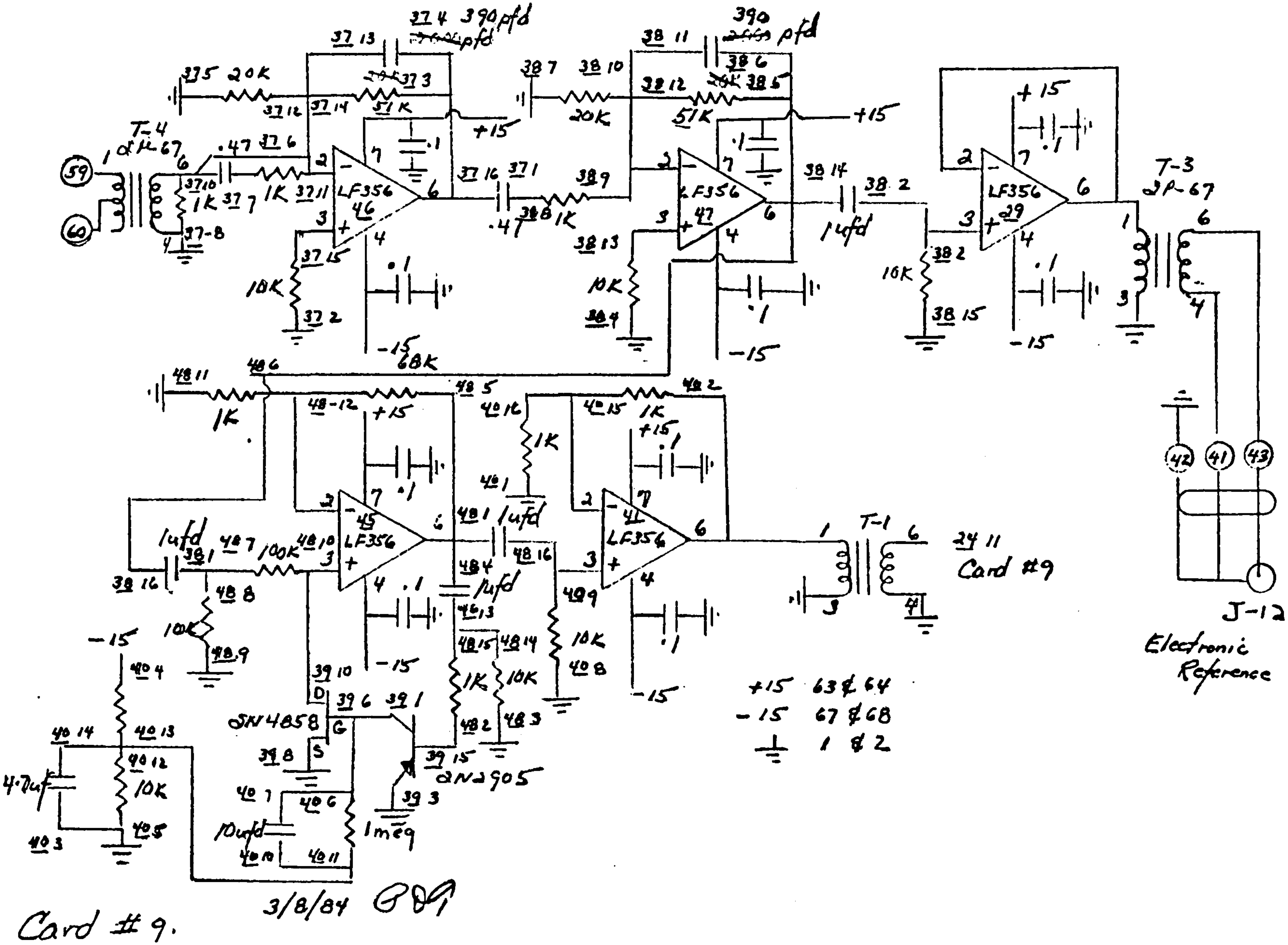


Figure 27: Reference Bandpass Amplifier and AGC, Card 9

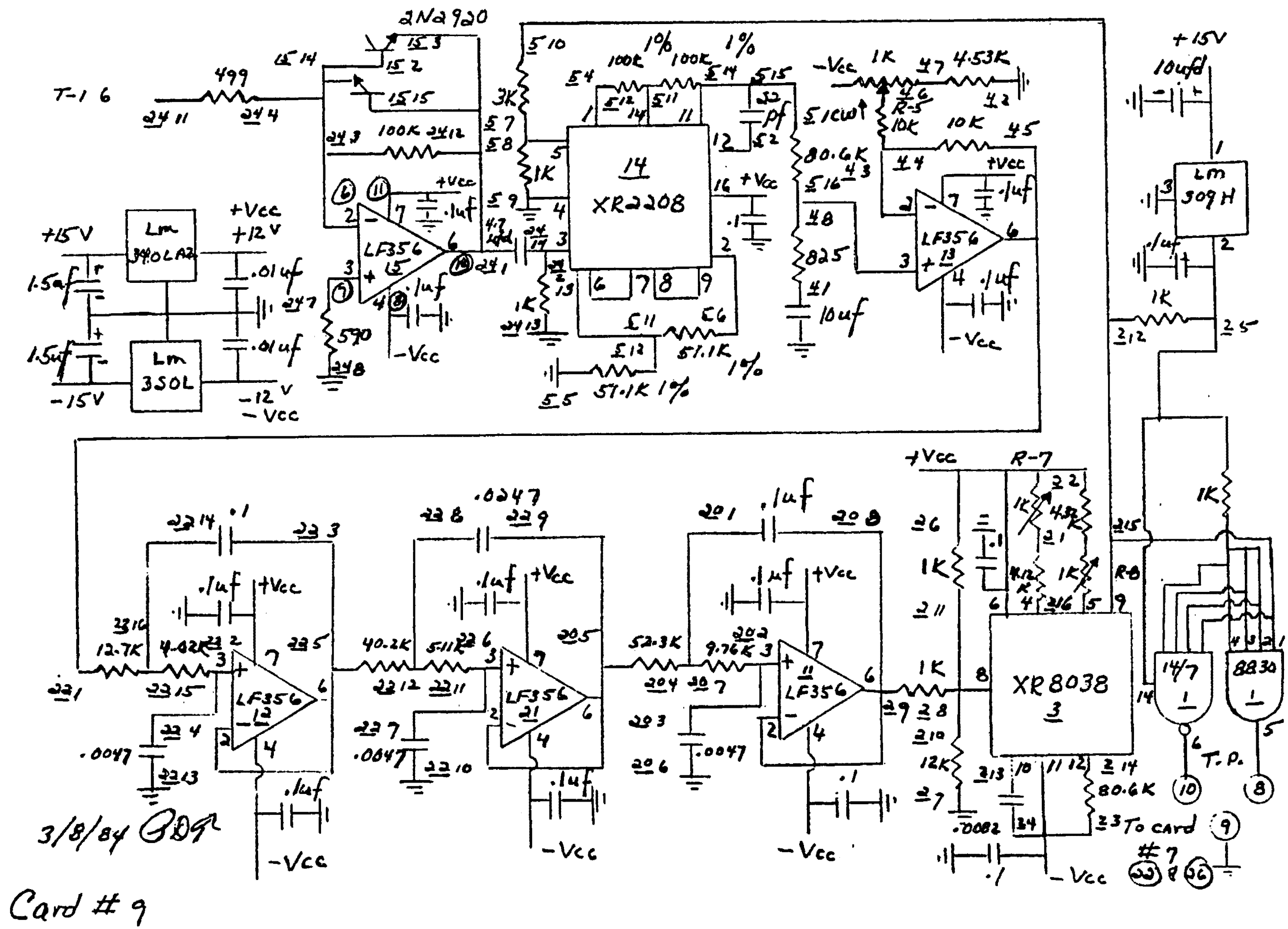


Figure 28: Reference Limiter and PLL, Card 9

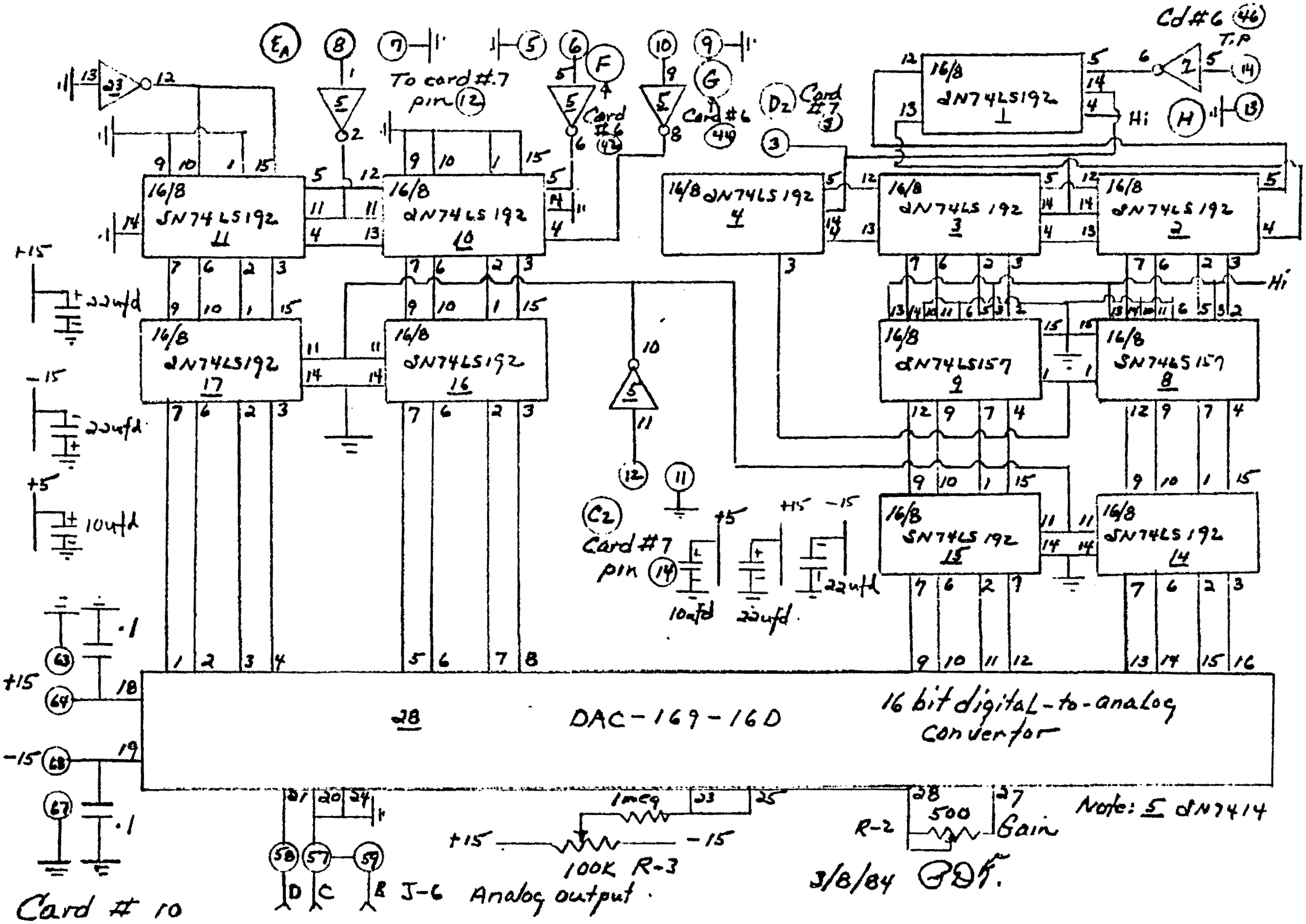


Figure 29: Analog Output, Card 10

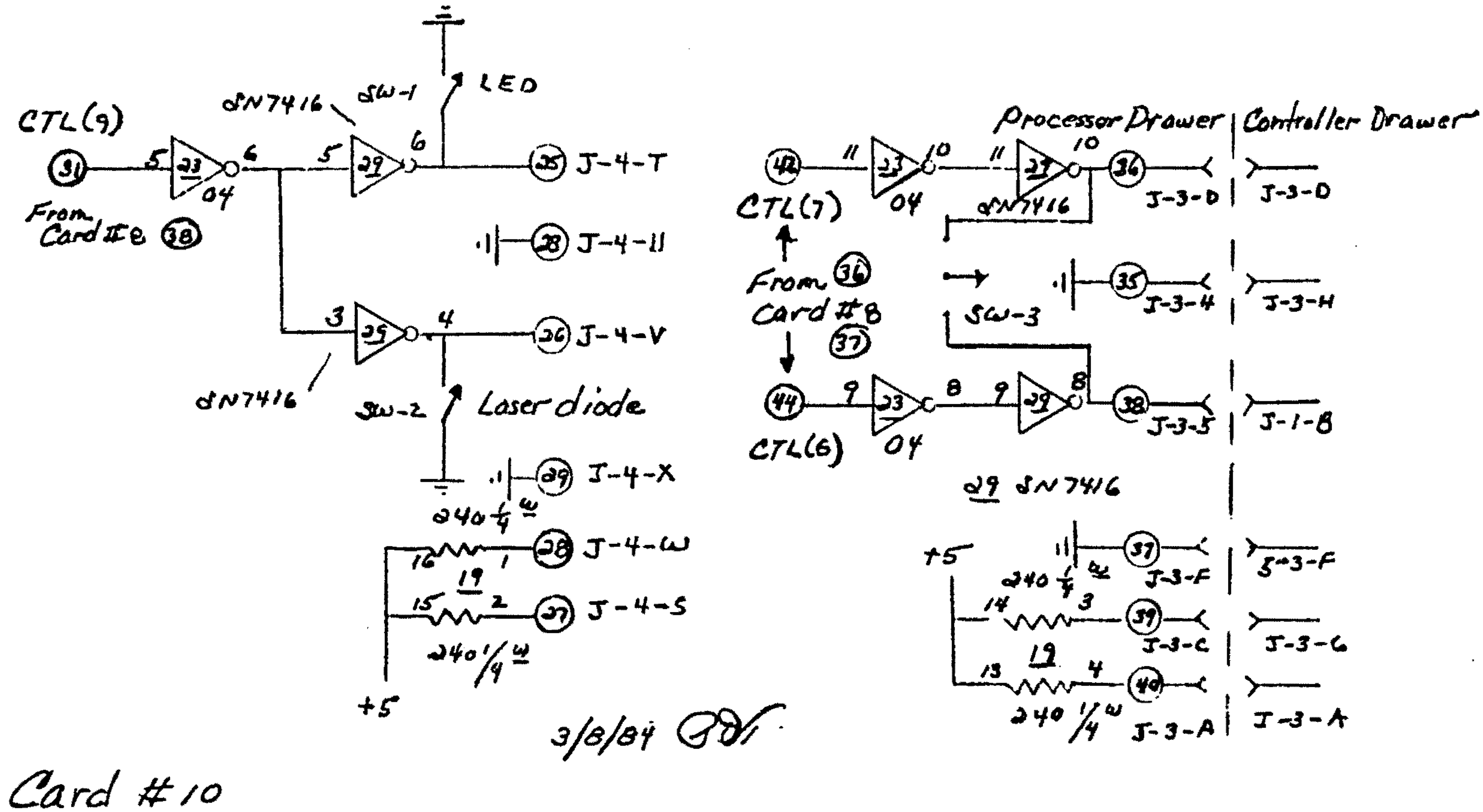


Figure 30: Manual Controls for LED's, Laser Diode, and Actuator, Card 10

Pin	Card 1	Card 2	Card 3
1	Ground	Ground	Ground
2			
3			
4			
5	BNC gnd. Blk	BNC gnd. Blk	
6	Shield ⏚ J-9	Shield J-11	
7	BNC out Red	BNC out Red	
8			
9			to Cd. 6 (53) ⏚
10			to Cd. 6 (51) I.R. Sig.
11	Shield ⏚	Shield ⏚	
12			
13	to Cd. 3 (28) Lo. green	to Cd. 4 (28) Lo. Blk	
14	to Cd. 3 (27) Hi. white	to Cd. 4 (27) Hi. Red	
15			
16			
17			
18			
19			
20			
21			
22			
23	to J4-A Orange	to J4-M green	
24	to J4-B white	to J4-N white	
25			
26			
27	+15VDC	+15VDC	to Cd. 1 (14) Hi white
28			to Cd. 1 (13) Lo green
29			
30			
31	-15VDC	-15VDC	
32			
33			
34			
35			
36			
37			
38			
39			
40			

Figure 31: Card Chassis Wiring, 1 of 6

Card 1	Card 2	Card 3
41 to BNC gnd white	41 to BNC gnd. white	41
42 Shield ⏚ J-8	42 Shield ⏚ J-10	42
43 to BNC Sig. Green	43 to BNC Sig. Green	43
44 to Cd. 5 (12) Sig. Prev..	44	44
45 T.P.	45	45 to Cd. 6 (47) ⏚ V.s. Sig. gnd.
46 to Cd. 5 (17) Sig. Prv. gnd	46	46 to Cd. 6 (45) V.s. Sig. T.P.
47 Shield ⏚	47	47
48	48	48
49 to Cd. 3 (60) Lo. Blk	49 to Cd. 4 (60) Lo green	49
50 to Cd. 3 (59) Hi Red	50 to Cd. 4 (59) Hi white	50
51	51	51
52	52	52
53	53	53
54	54	54
55	55	55
56	56	56
57	57	57
58	58	58
59 to J4-C Hi Red	59 to J4-K Hi Red	59 to Cd. 1 (50) Hi Red
60 to J4-D Lo Blk	60 to J4-L Lo Blk	60 to Cd. 1 (49) Lo. Blk
61	61	61
62	62	62
63 +15 VDC	63 +15 VDC	63 +15 VDC
64	64	64
65	65	65
66	66	66
67 −15 VDC	67 −15 VDC	67 −15 VDC
68	68	68
69	69	69
70	70	70
71 +5 VDC	71 +5 VDC	71 +5 VDC
72	72	72

Figure 32: Card Chassis Wiring, 2 of 6

Card 4	Card 5	Card 6
1 Ground	1 Ground	1 Ground
2	2	2
3	3 to Cd. 8 24	3 to Cd. 8 24
4	4 to Cd. 8 23	4 to Cd. 8 23
5	5 to Cd. 8 22	5 to Cd. 8 22
6	6 to Cd. 8 21	6 to Cd. 8 21
7	7 to Cd. 8 20	7 to Cd. 8 20
8	8 to Cd. 8 19	8 to Cd. 8 19
9 to Cd. 5 47 } Vis. Sig.	9 to Cd. 8 18	9 to Cd. 8 18
10 to Cd. 5 45 } Vis. Sig.	10 to Cd. 8 17	10 to Cd. 8 17
11	11 to Cd. 8 8 Add 4	11 to Cd. 8 6 Add 2
12	12 to Cd. 1 44 Sig. Pre.	12
13	13 to Cd. 7 29 B	13 to Cd. 7 27 B
14	14 to Cd. 6 25 Sig. Pre.	14
15	Typ. 15 to Cd. 7 20 A	15 to Cd. 7 18 A
16	16 to Cd. 8 35 CTL·6	16
17	17 to Cd. 1 46 Sig. Pre. Gnd.	17
18	18	18
19	19	19
20	20	20
21	21	21
22	22	22
23	23	23
24	24	24
25	25	25 to Cd. 5 14 Sig. Pre.
26	26	26
27 to Cd. 2 14 Hi white	27 to Cd.	27
28 to Cd. 2 13 Lo Blk.	28	28
29	29 to Cd. 7 10 ER	29 to Cd. 7 9 EM
30	30	30
31	31 to Cd. 7 15 C1	31 to Cd. 7 11 C
32	32	32
33	33 to Cd. 8 14 Add 9	33 to Cd. 8 10 Add 5
34	34	34
35	35	35
36	36	36
37	37 to Cd. 8 13 Add 10	37 to Cd. 8 9 Add 6
38	38	38
39	39 to Cd. 7 51 } 2.7MHz	39 to Cd. 7 51 } 2.7MHz
40	40 to Cd. 7 52 } 2.7MHz	40 to Cd. 7 52 } 2.7MHz

Figure 33: Card Chassis Wiring, 3 of 6

Card 4		Card 5		Card 6	
41		41 to Cd. 7 47	start Ref. Vis. T.P.	41 to Cd. 7 41	start mod. Vis T.P.
42		42		42 to Cd. 10 6 F	
43		43 to Cd. 7 45		43 to Cd. 7 43	
44		44		44 to Cd. 10 10 G	
45 to Cd. 5 53	I.R. Ref.	45 to Cd. 4 10	Vis. Ref.	45 to Cd. 3 46	Vis. Sig.
46 to Cd. 5 51		46		46 to Cd. 10 14 H	
47		47 to Cd. 4 9		47 to Cd. 3 45	
48		48		48	
49		49 to Cd 8 15 Add 12		49 to Cd. 8 11 Add 8	
50		50		50	
51		51 to Cd. 4 46	I.R. Ref.	51 to Cd. 3 10	I.R. Sig.
52		52		52	
53		53 to Cd. 4 45		53 to Cd 3 9	
54		54 to Cd. 7 48	start I.R. Ref.	54 to Cd. 7 42	start I.R. mod.
55		55 to Cd. 7 46		55 to Cd. 7 44	
56		56		56	
57		57 to Cd. 7 17 D		57 to Cd. 7 16 D	
58		58		58	
59 to Cd. 2 50 Hi white		59		59	
60 to Cd. 2 49 Lo green		60 to Cd. 8 16 Add 11		60 to Cd. 8 12 Add 7	
61		61		61	
62		62		62	
63	+15VDC	63	+15VDC	63	+15VDC
64		64		64	
65		65		65	
66		66		66	
67	−15VDC	67	−15VDC	67	−15VDC
68		68		68	
69		69		69	
70		70		70	
71	+5VDC	71	+5VDC	71	+5VDC
72		72		72	

Figure 34: Card Chassis Wiring, 4 of 6

Card 7	Card 8	Card 9	Card 10
1	1	1	1
2 Ground	2 Ground	2 Ground	2 Ground
3 to Cd. 10 3 D2	3 to Cd. 7 25 Add 0	3	3 to Cd. 7 3 D2
4 to Cd. 8 4	4 to Cd. 7 4	4	4
5 to Cd. 8 31 CTL-2	5 Reset to front panel	5	5
6 to Cd. 8 32 CTL-3	6 to Cd. 6 11 Add 2	6	6 to Cd. 5+6 42 F
7 to Cd. 8 33 CTL-4	7 Reset gnd.	7	7
8 to Cd. 8 34 CTL-5	8 to Cd. 5 11 Add 4	8 to Cd. 7 26 Ref. P.L.L.	8 to Cd. 7 12 EA
9 to Cd. 6 29 EM	9 to Cd. 6 37 Add 6	9 Shield	9
10 to Cd. 5 29 ER	10 to Cd. 6 33 Add 5	10 to Cd. 7 22	10 to Cd. 5+6 44 G
11 to Cd. 6 31 C	11 to Cd. 6 49 Add 8	11	11
12 to Cd. 10 8 EA	12 to Cd. 6 60 Add 7	12	12 to Cd. 7 14 C2
13 to	13 to Cd. 5 37 Add 10	13	13
14 to Cd. 10 12 C2	14 to Cd. 5 33 Add 9	14	14 to Cd. 5+6 46 H
15 to Cd. 5 31 C1	15 to Cd. 5 49 Add 12	15	15
16 to Cd. 6 57 D	16 to Cd. 5 60 Add 11	16	16
17 to Cd. 5 57 D1	17 to Cd. 5+6 10	17	17
18 to Cd. 6 15 A	18 to Cd. 5+6 9	18	18
19	19 to Cd. 5+6 8	19	19
20 to Cd. 5 15 A	20 to Cd. 5+6 7	20	20
21	21 to Cd. 5+6 6	21	21
22 to Cd. 9 10 Ref. P.L.L. white	22 to Cd. 5+6 5	22	22
23	23 to Cd. 5+6 4	23	23 to J4-U
24 to Cd 9 9 Ref. P.L.L. shield	24 to Cd. 5+6 3	24	24
25 to Cd 8 3 Add 0	25 mirror motor J4-F T.P.	25	25 to J4-T
26 to Cd 9 8 Ref. P.L.L. green	26 mirror J4-W	26	26 to J4-V
27 to Cd. 6 3 B	27	27	27 to J4-S
28	28	28	28 to J4-W
29 to Cd 5 13 B	29	29	29 to J4-X
30	30	30	30
31	31 to Cd. 7 5 CTL-2	31	31 to Cd. 8 38 CTL-9
32	32 to Cd. 7 6 CTL-3	32	32
33	33 to Cd. 7 7 CTL-4	33	33
34	34 to Cd. 7 8 CTL-5	34	34
35	35 to Cd. 5 14 CTL-6	35	35 to J3-H
36	36 to Cd. 10 42 CTL-7	36	36 to J3-D T.P.
37	37 to Cd. 10 44 CTL-8	37	37 to J3-F
38	38 to Cd. 10 31 CTL-9	38	38 to J3-B
39	39	39	39 to J3-C
40	40	40	40 to J3-A

Figure 35: Card Chassis Wiring, 5 of 6 .

Card 7	Card 8	Card 9	Card 10
41 to Cd. 6 41 J.P. start Mod.	41	41 J-12 low Blk	41
42 to Cd. 6 54 Vis.	42	42 J-12 ⏚	42 to Cd. 8 36 CTL-7
43 to Cd. 6 43 start Mod.	43 J-12 Hi Red	43 J-12 Hi Red	43
44 to Cd. 6 55 T.P. I.R.	44 to J7-1 DIO1	44	44 to Cd. 8 37 CTL-8
45 to Cd. 5 43 start Ref. Vis.	45 to J7-2 DIO2	45	45
46 to Cd. 5 65 start Ref. I.R.	46 to J7-3 DIO3	46	46
47 to Cd. 5 41 J.P.	47 to J7-4 DIO4	47	47
48 to Cd. 5 54 J.P.	48 to J7-5 EOI	48	48
49	49 to J7-8 NDAC	49	49
50	50 to J7-9 IFC	50	50
51 to Cd. 5+6 39 2.7MHz	51 to J7-10 SRQ	51	51
52 to Cd. 5+6 40	52 to J7-12 ⏚ shield	52	52
53	53 to J7-13 DIO5	53	53
54	54 to J7-14 DIO6	54	54
55	55 to J7-15 DIO7	55	55
56	56 to J7-16 DIO8	56	56
57	57 to J7-17 REN	57	57 DAC Gnd J6-C
58	58 to J7-6 DAV	58	58 DAC out J6-D
59	59 to J7-7 NRFD	59	59 DAC shield J6-B
60	60 to J7-11 ATN	60	60
61	61 to J7-24 ⏚ BRN	61	61
62	62	62	62
63 +15VDC	63 +15VDC	63 +15VDC	63 +15VDC
64	64	64	64
65	65	65	65
66	66	66	66
67 −15VDC	67 −15VDC	67 −15VDC	67 −15VDC
68	68	68	68
69	69	69	69
70	70	70	70
71 +5VDC	71 +5VDC	71 +5VDC	71 +5VDC
72	72	72	72

Figure 36: Card Chassis Wiring, 6 of 6

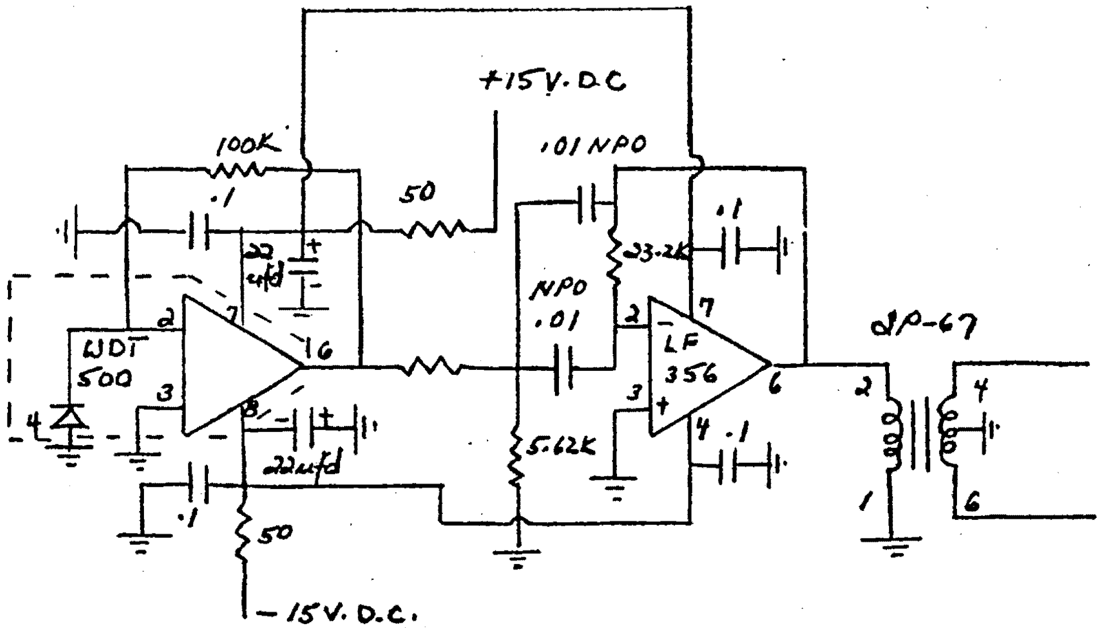


Figure 37: Signal Detectors, Enclosure 2, 3, 4, 5

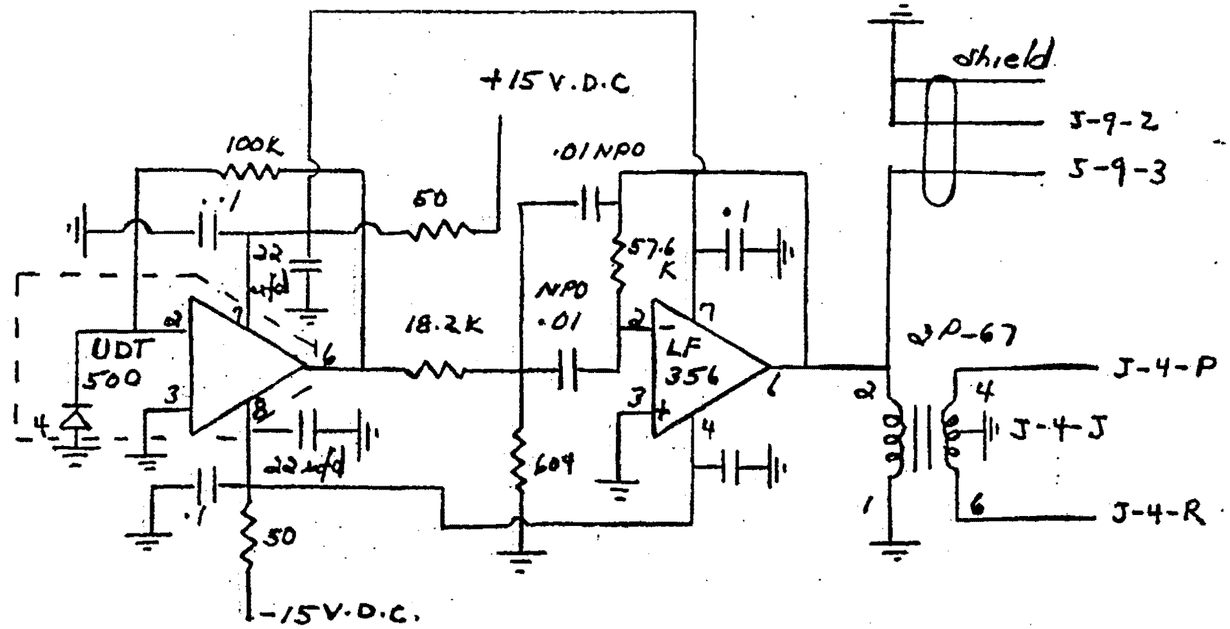


Figure 38: Reference Detector, Enclosure 1

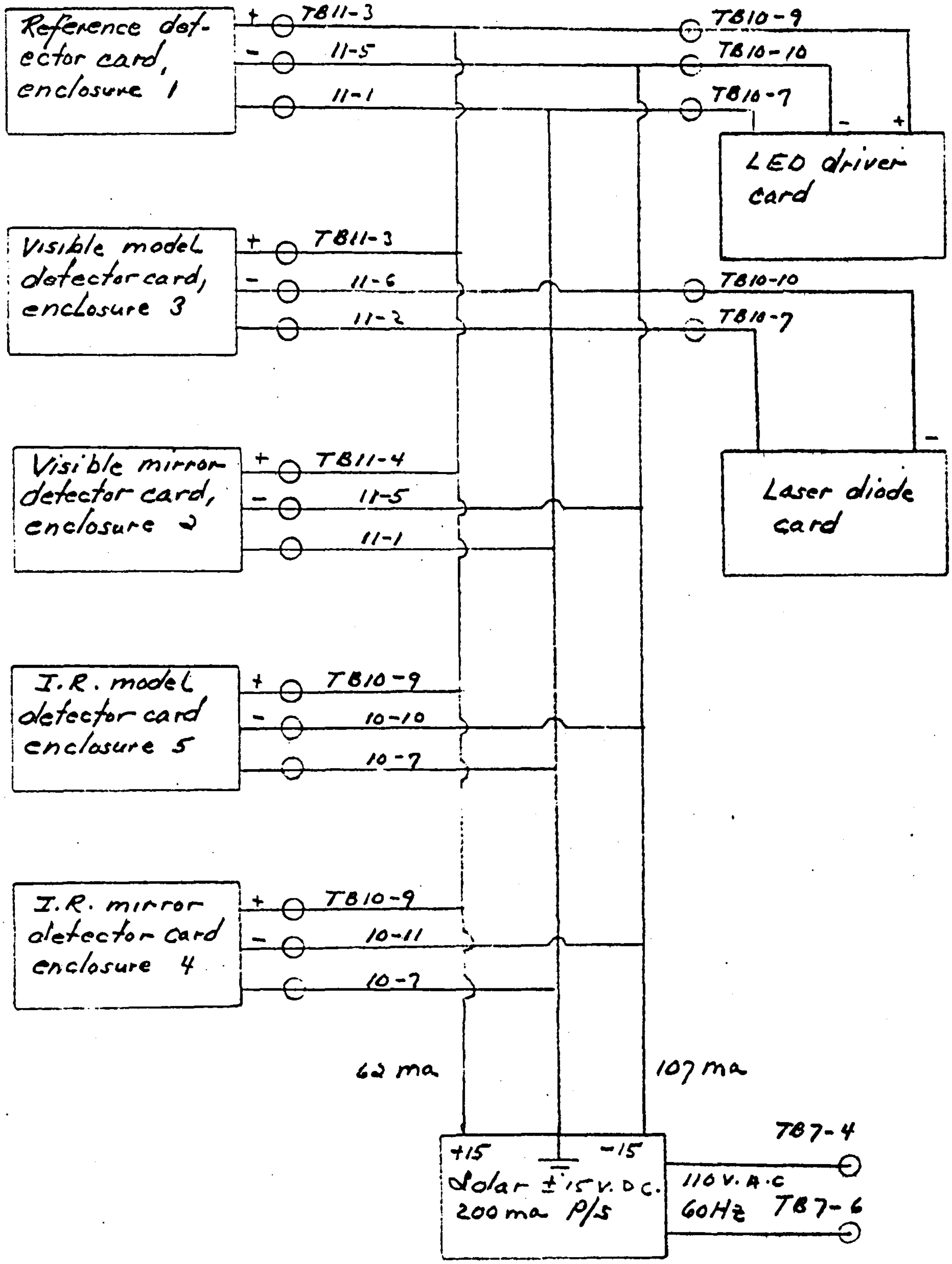


Figure 39: Wiring Diagram of Optical Assembly

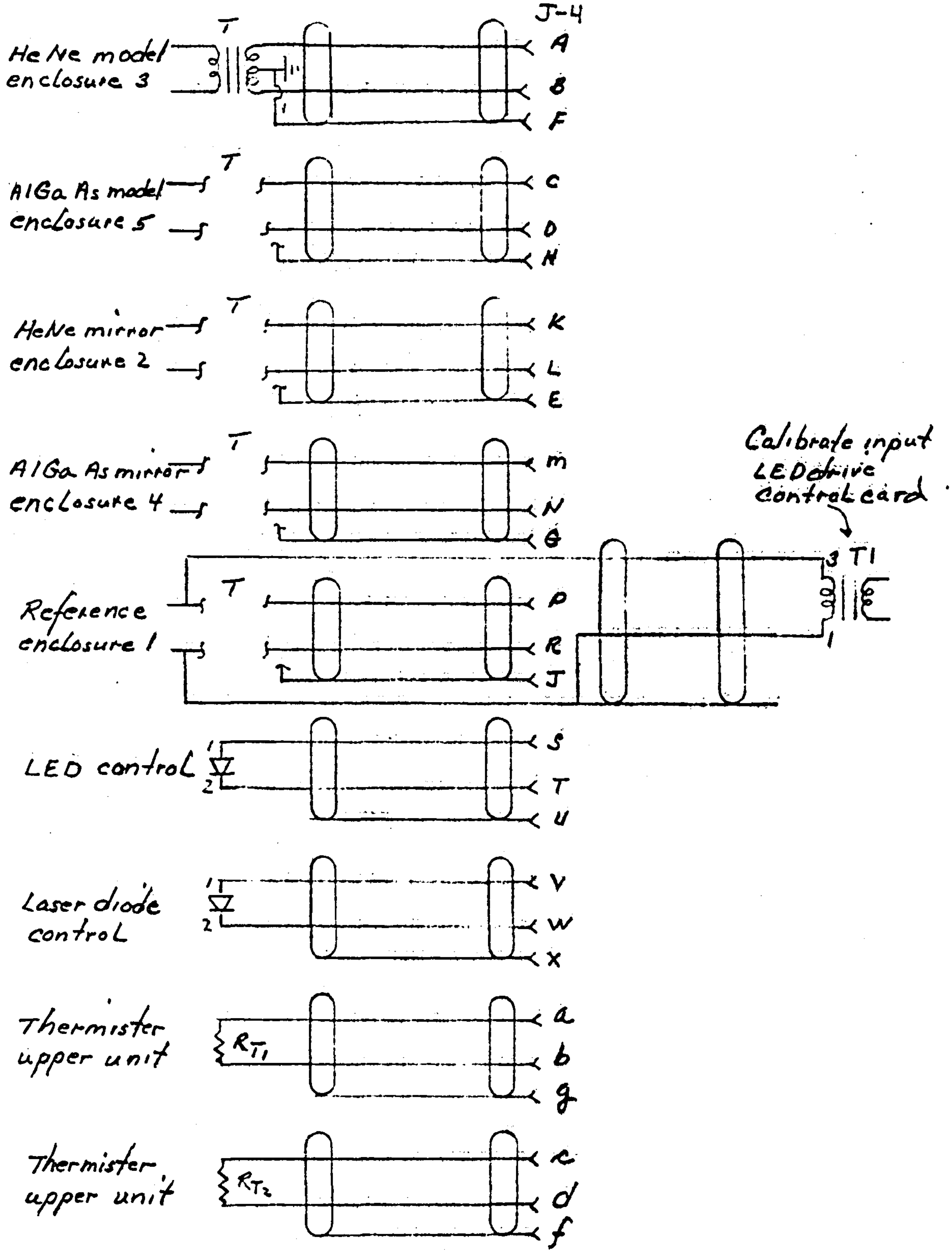


Figure 40: Interface Wiring of Optical Assembly

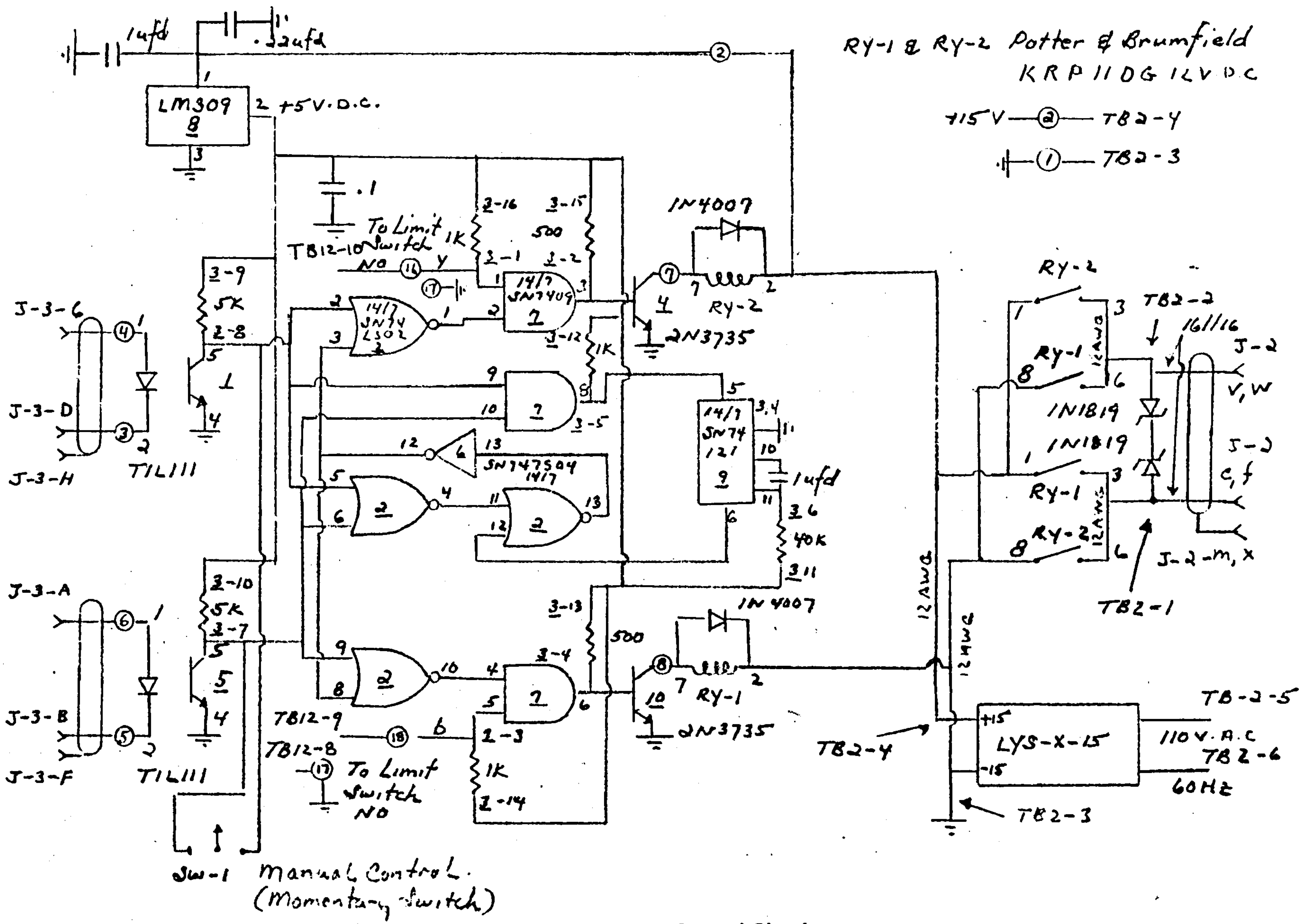


Figure 41: Actuator Control Circuit

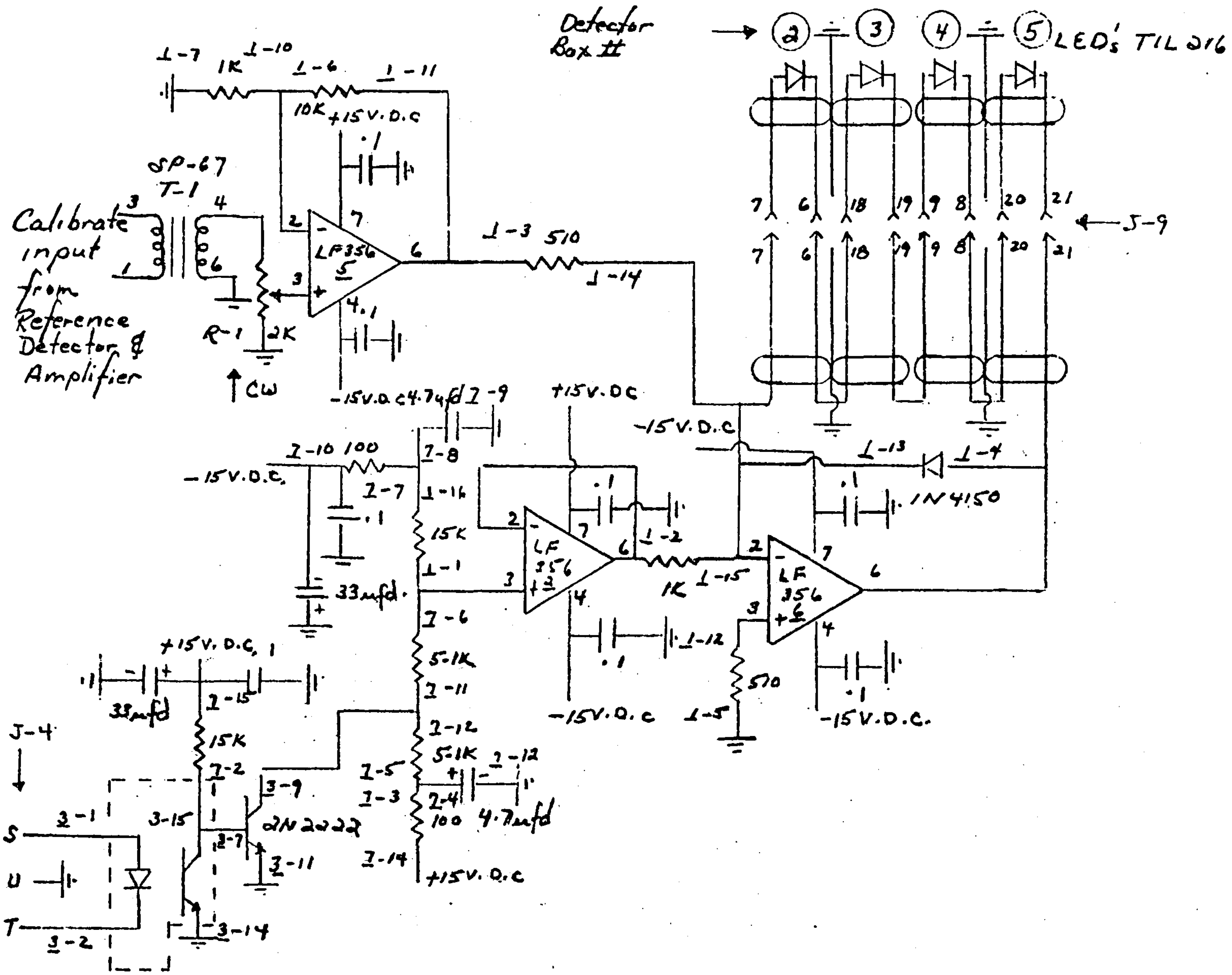


Figure 42: LED Drive and Control, Optical Assembly

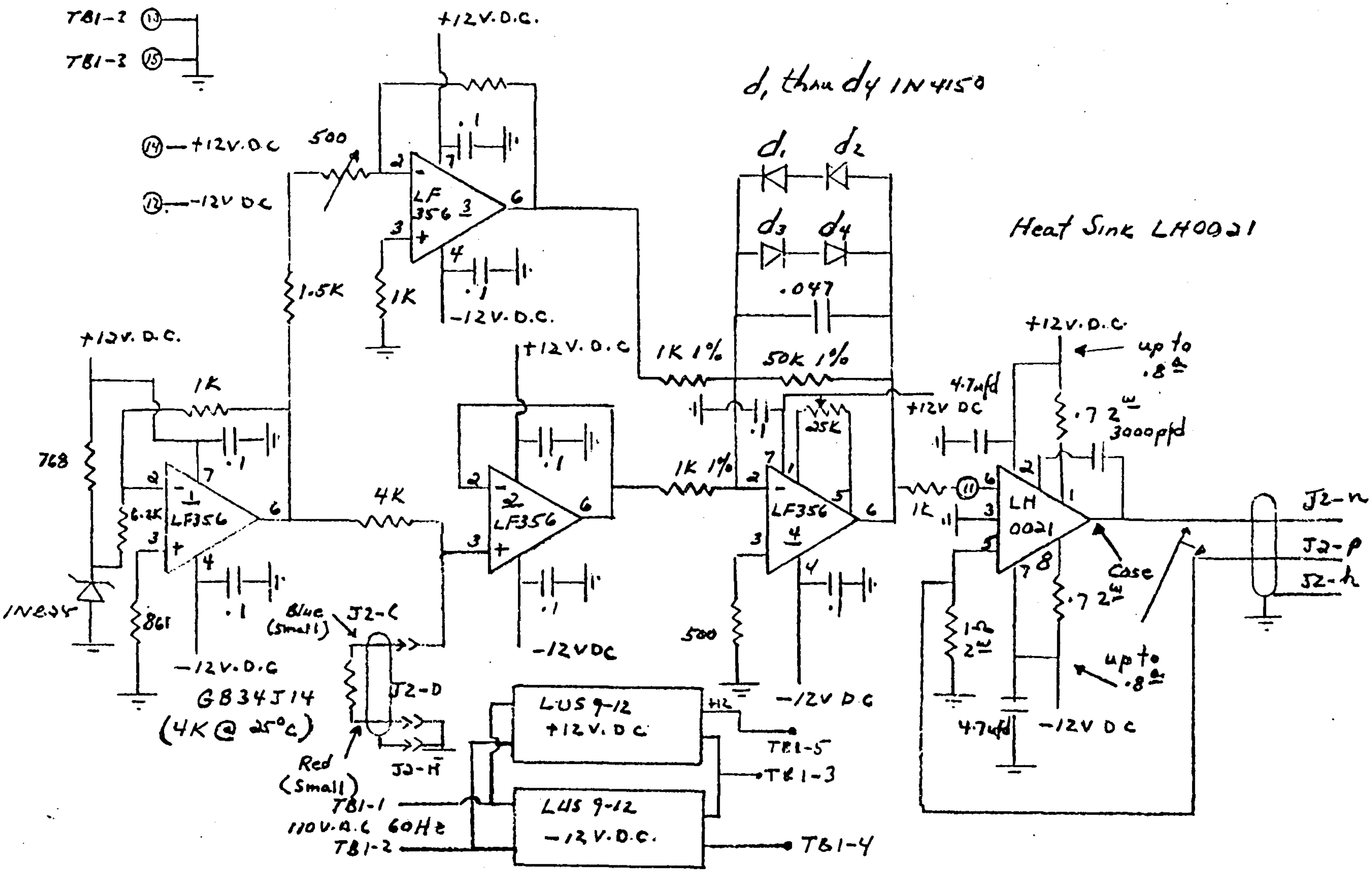


Figure 43: Thermoelectric Controller, Controller Chassis

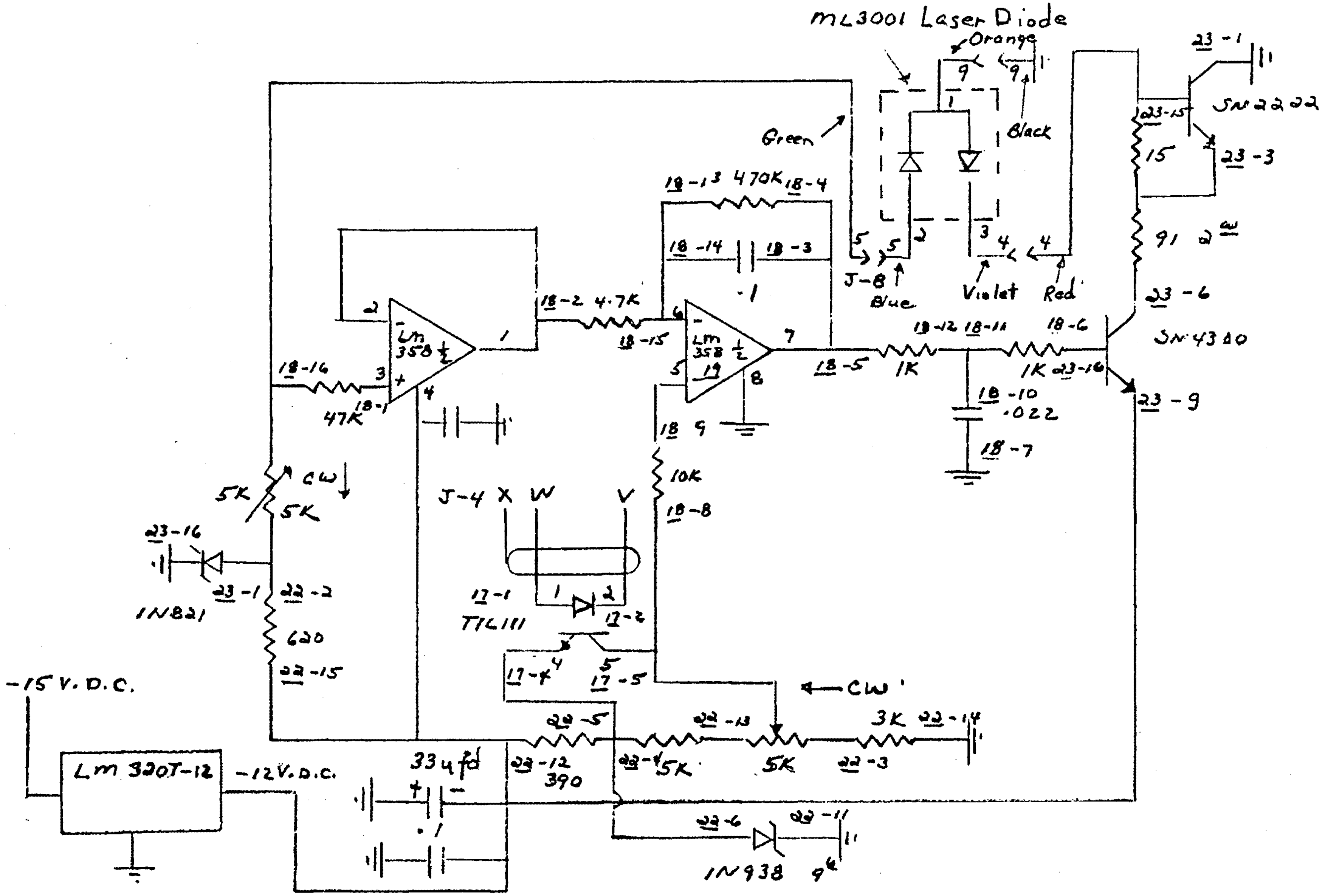


Figure 44: Laser Diode and Control, Optical Assembly

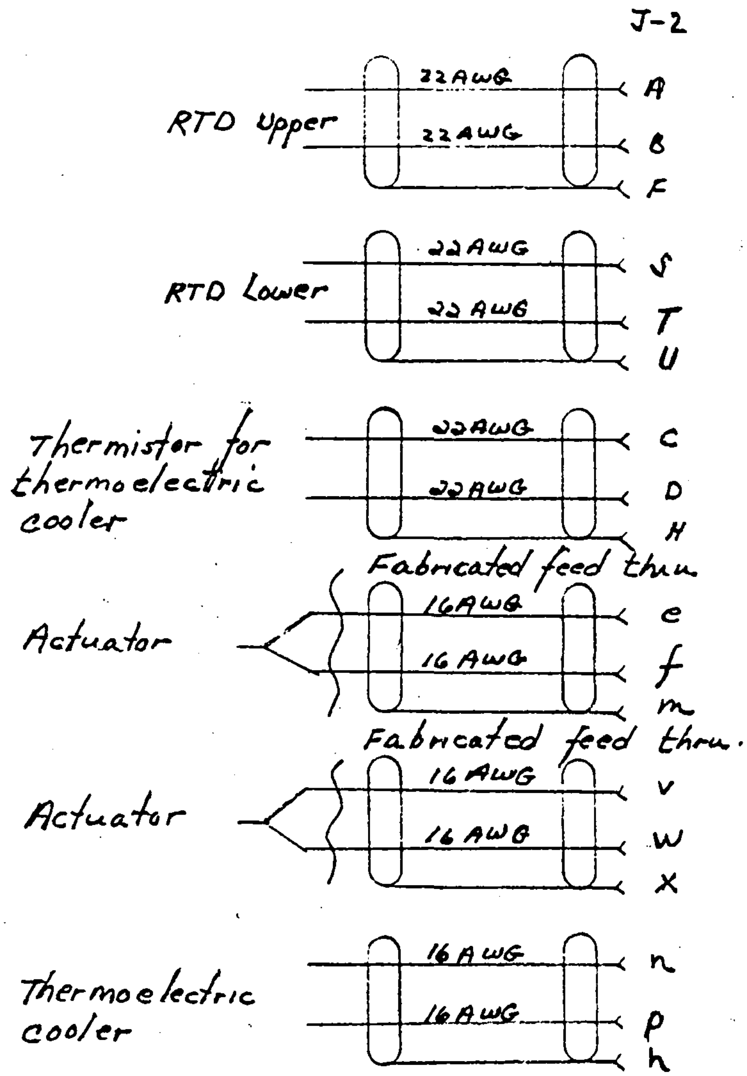


Figure 45: Wiring Diagram of J-2 at Optical Assembly

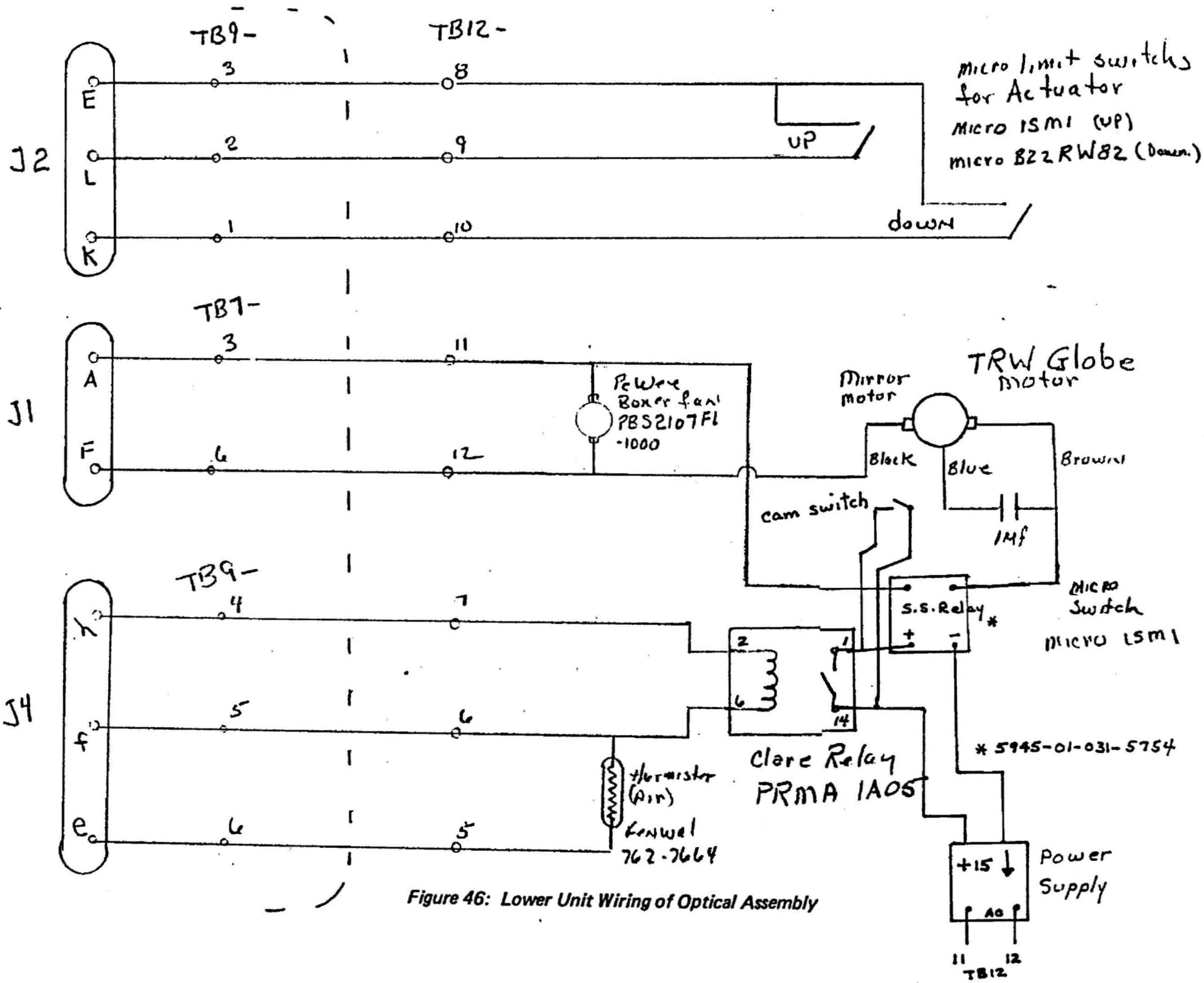


Figure 46: Lower Unit Wiring of Optical Assembly

(See Addendum Page 179)

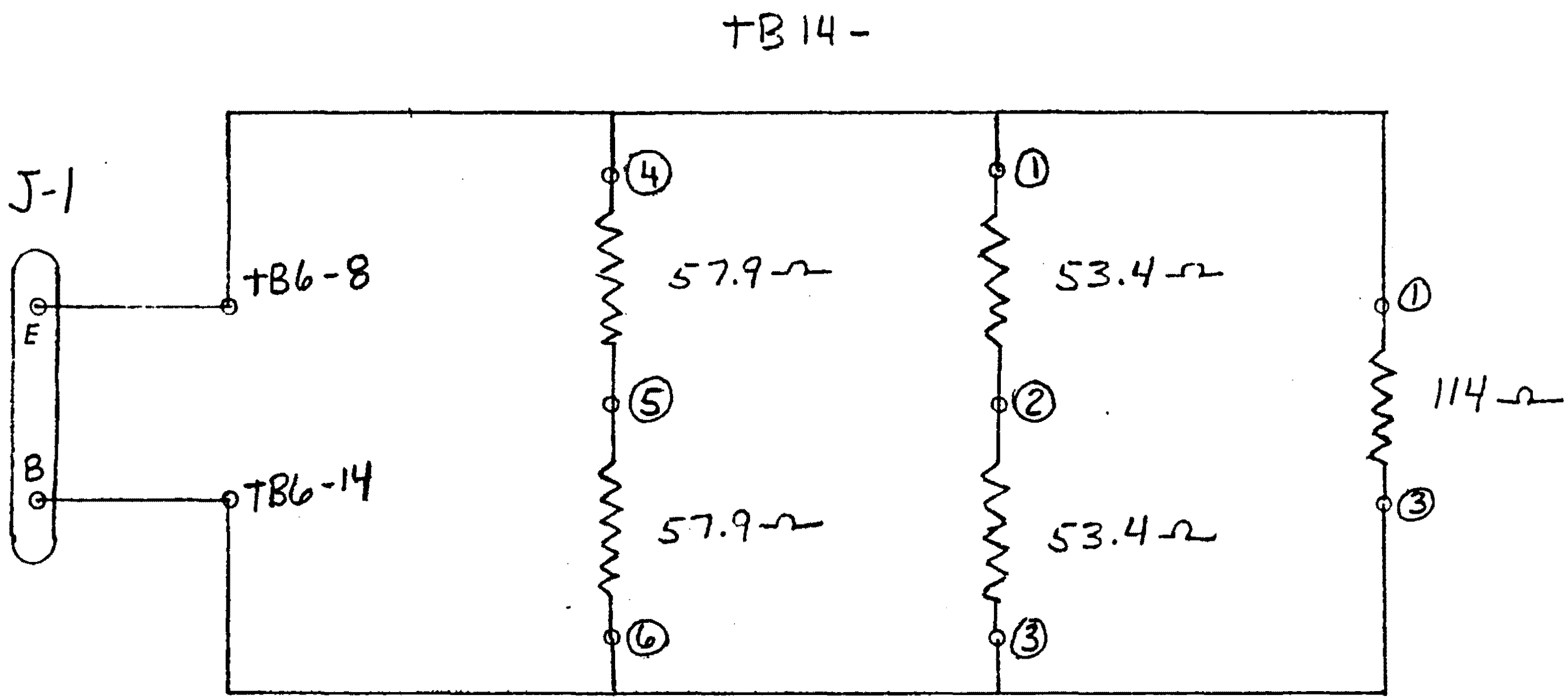


Figure 47: Heaters, Upper Unit

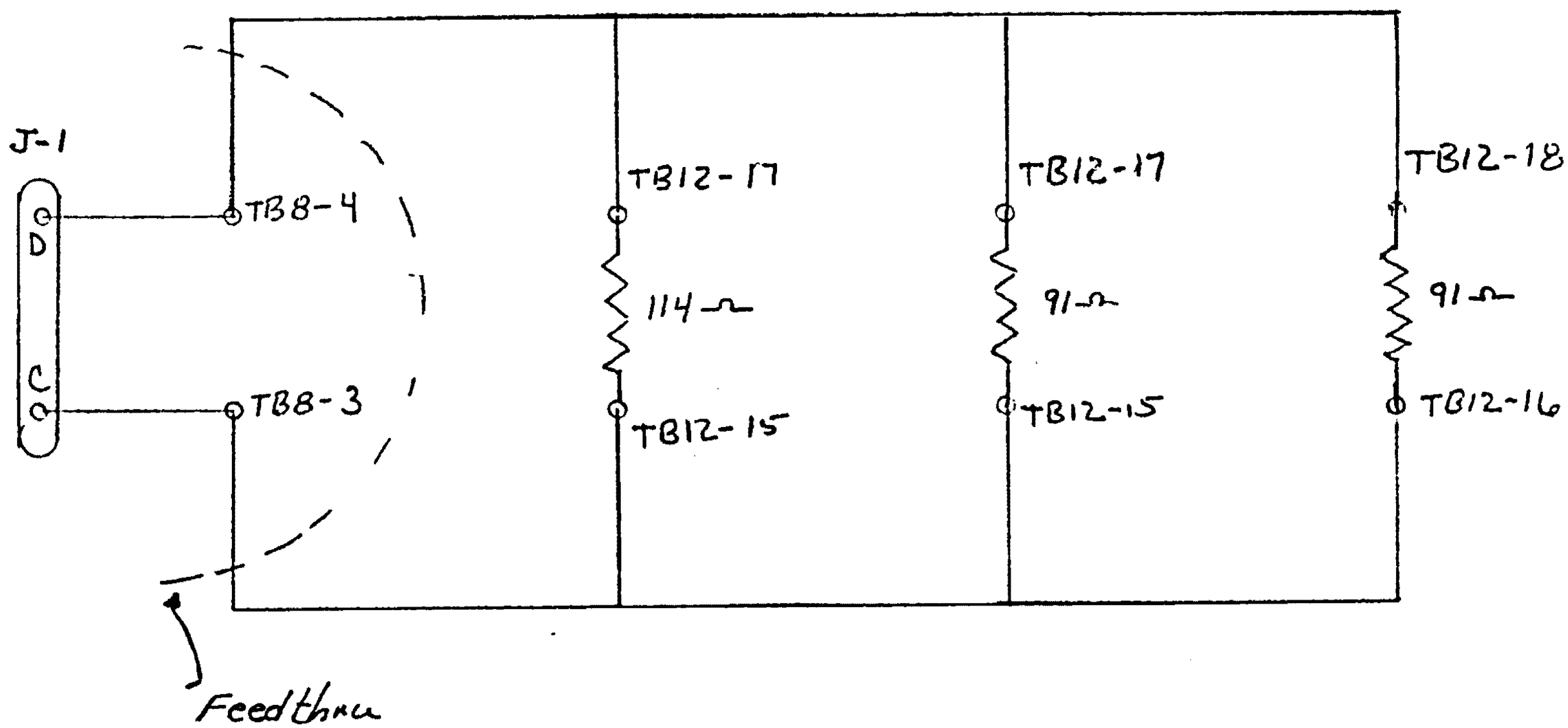


Figure 48: Heaters, Lower Unit

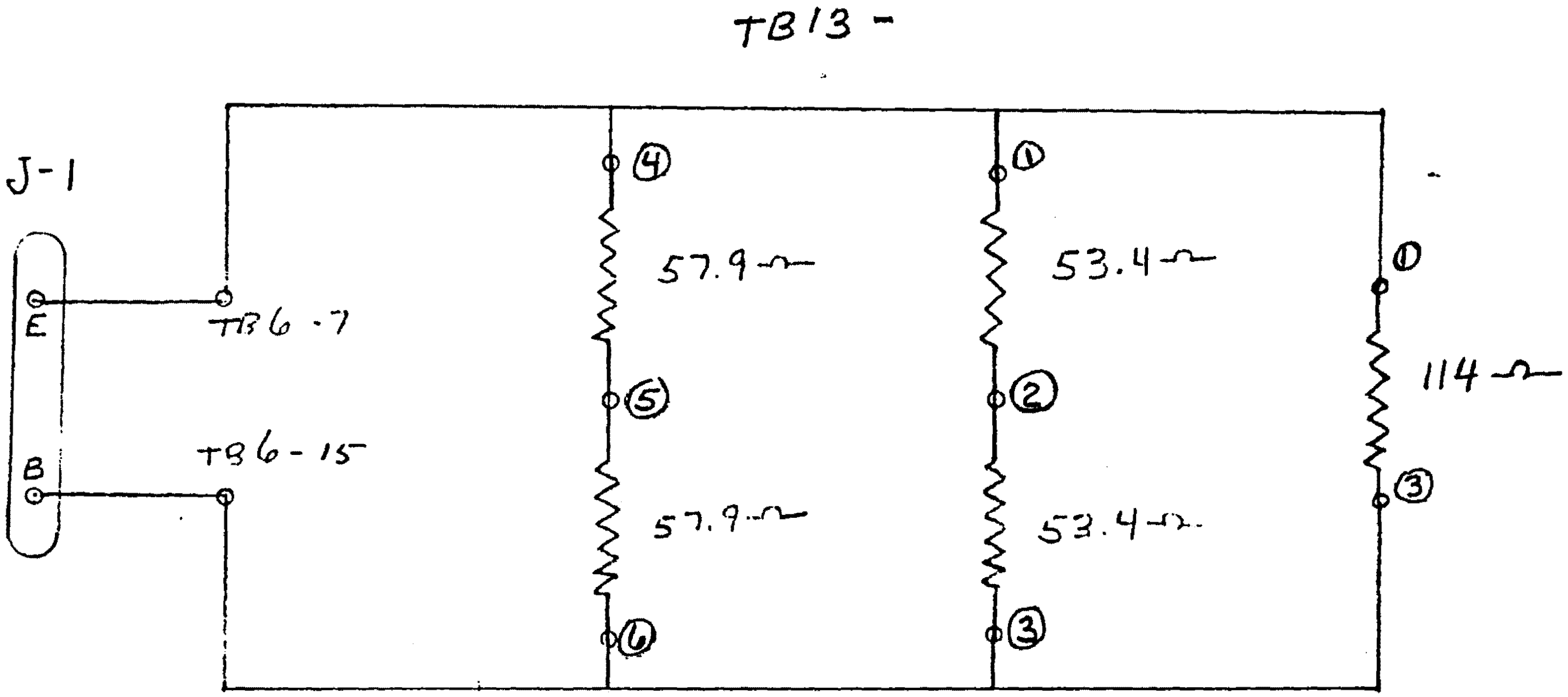


Figure 49: Heaters, Upper Unit Lid

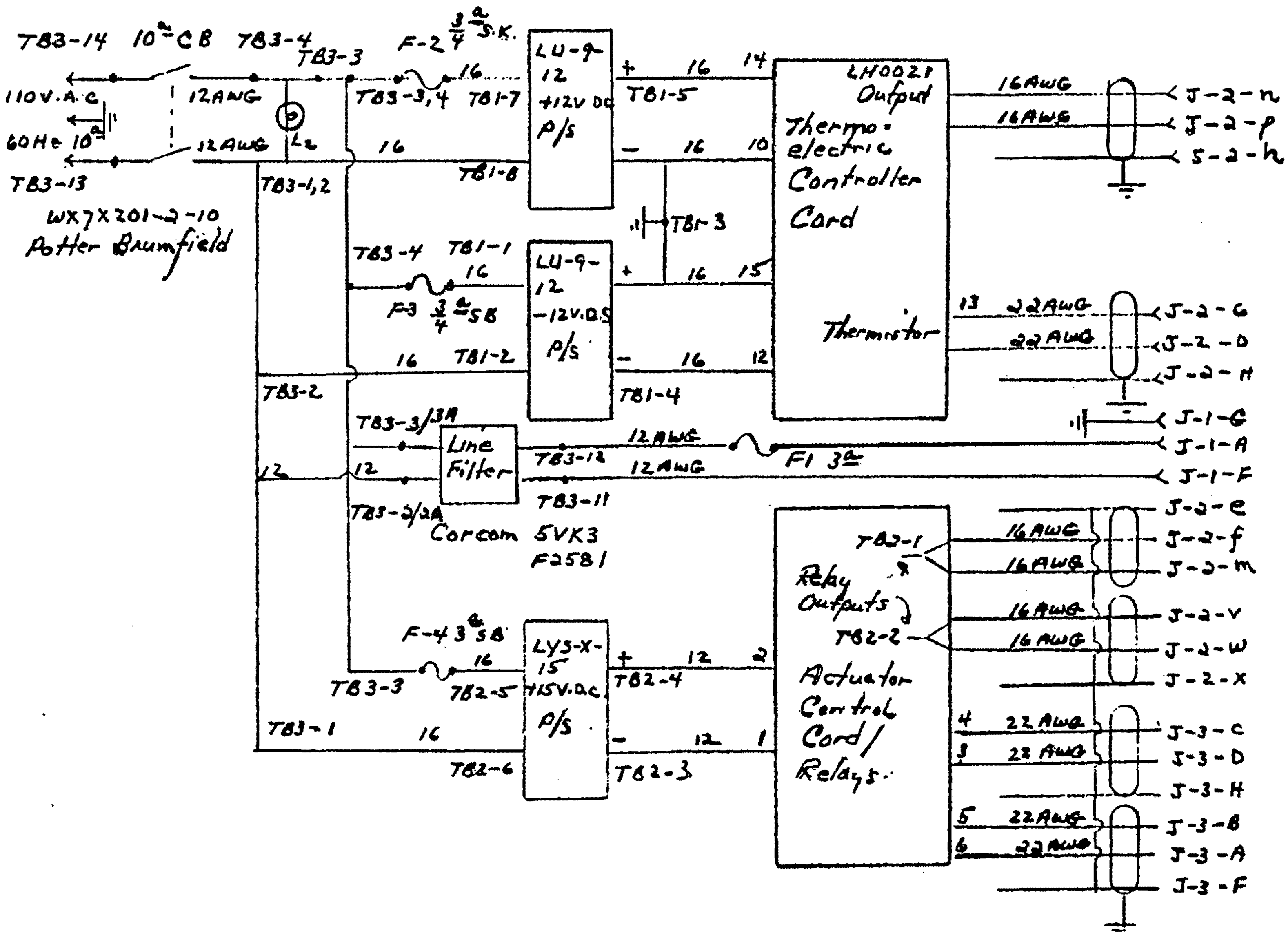


Figure 50: Controller Chassis Wiring, 1 of 2

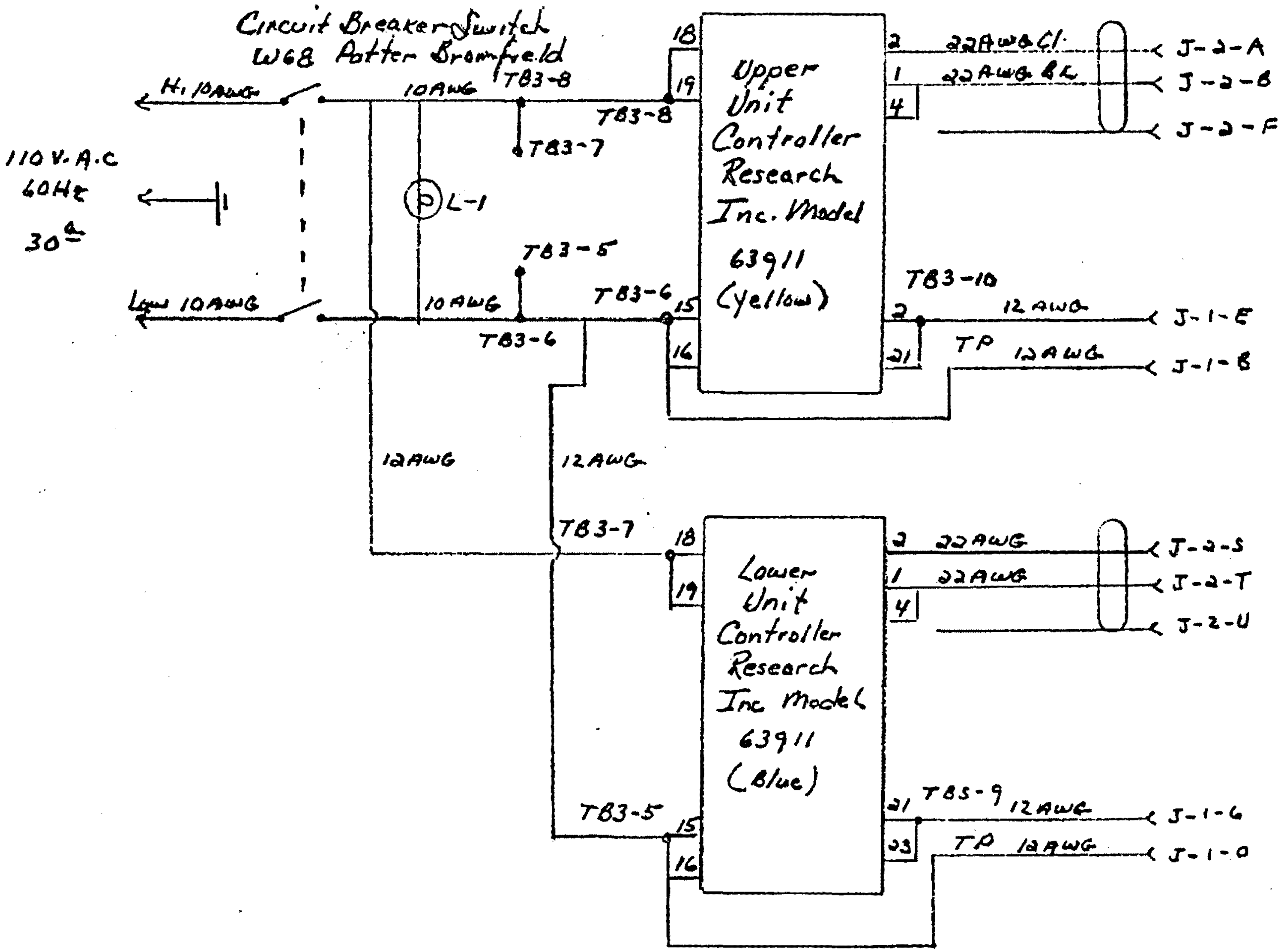


Figure 51: Controller Chassis Wiring, 2 of 2

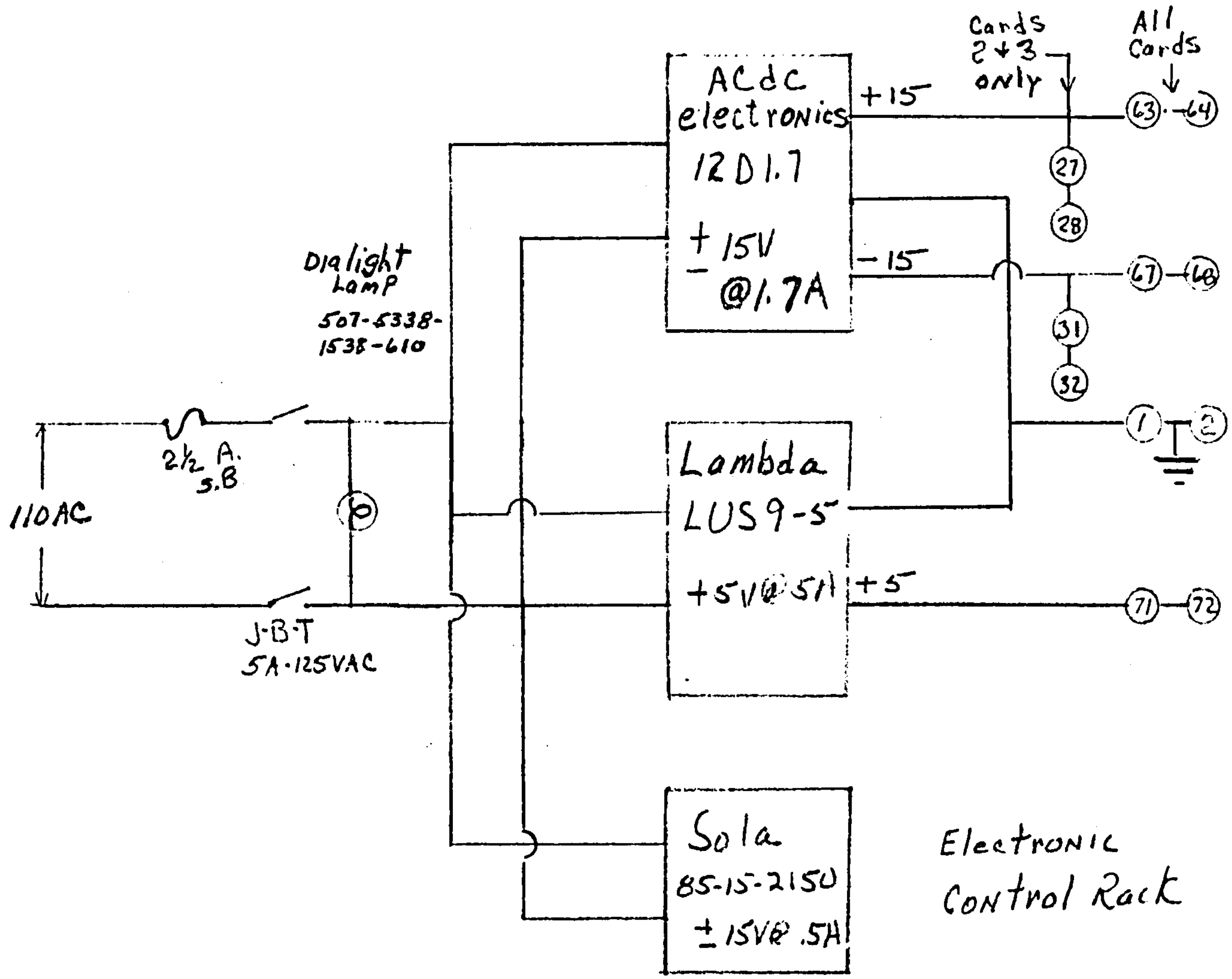


Figure 52: D.C. Power Supply Wiring, Controller Drawer

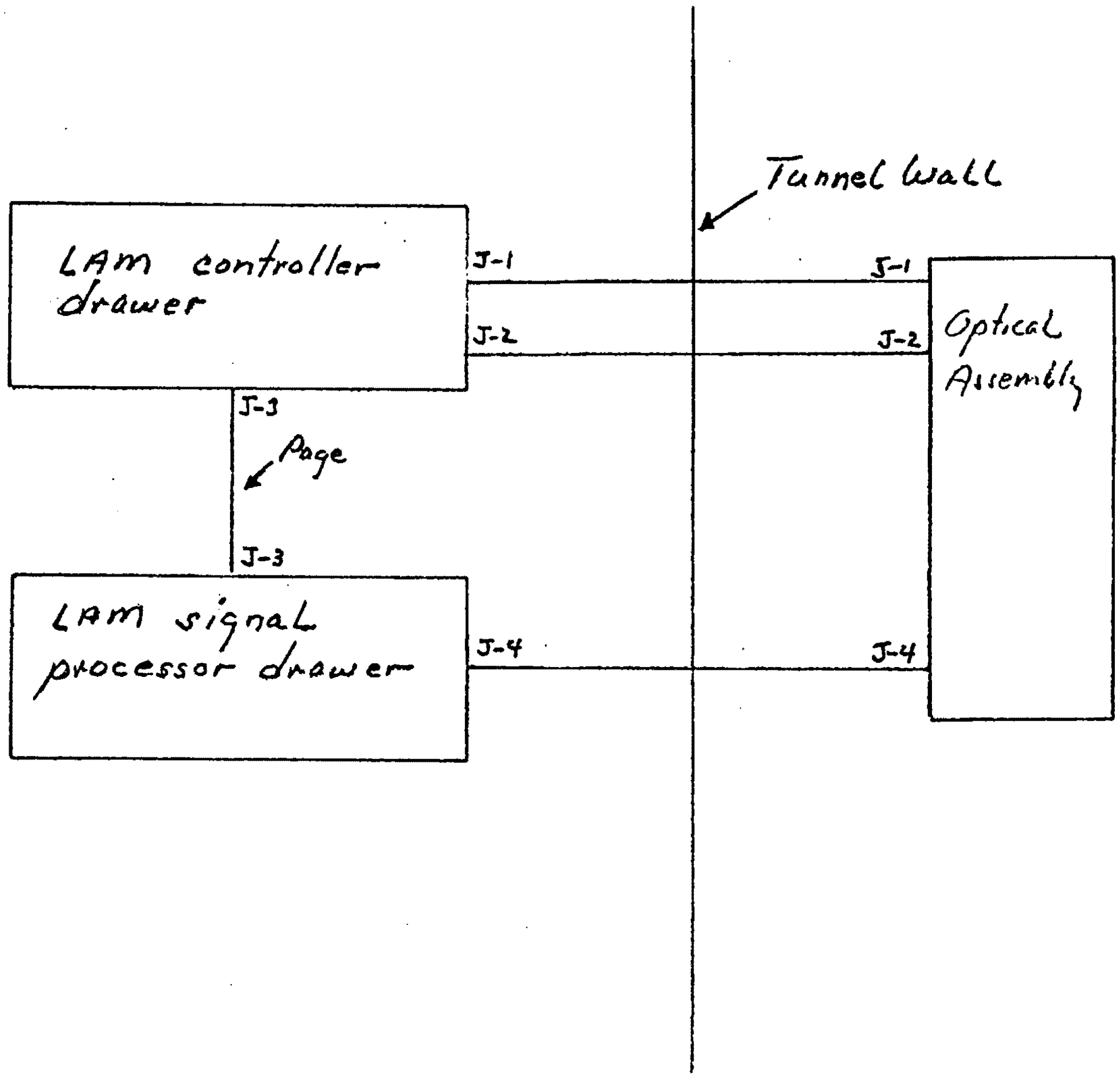


Figure 53: Block Diagram of Interconnecting Cables

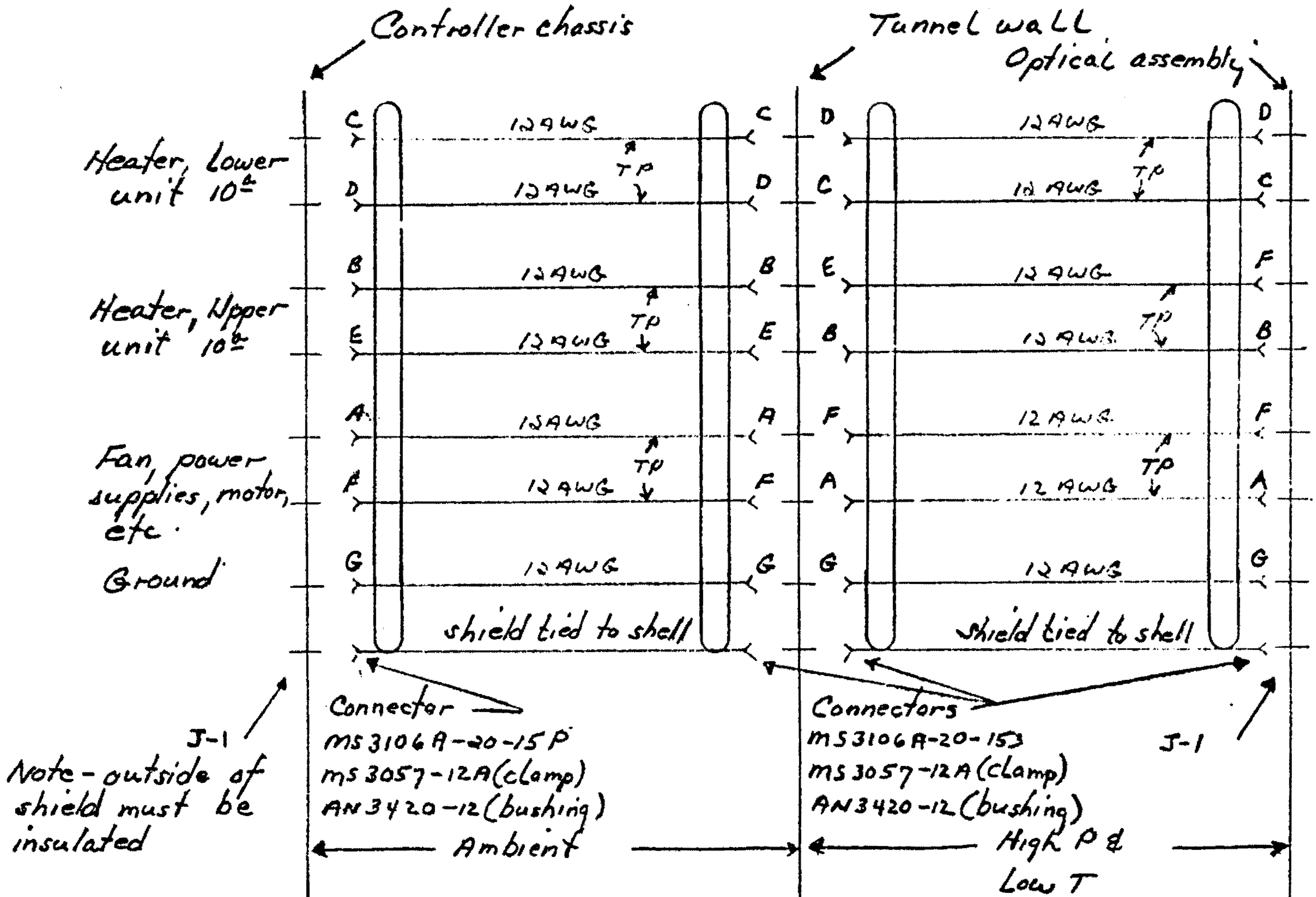


Figure 54: Wiring Diagram for Cable With Connectors Labelled J-1

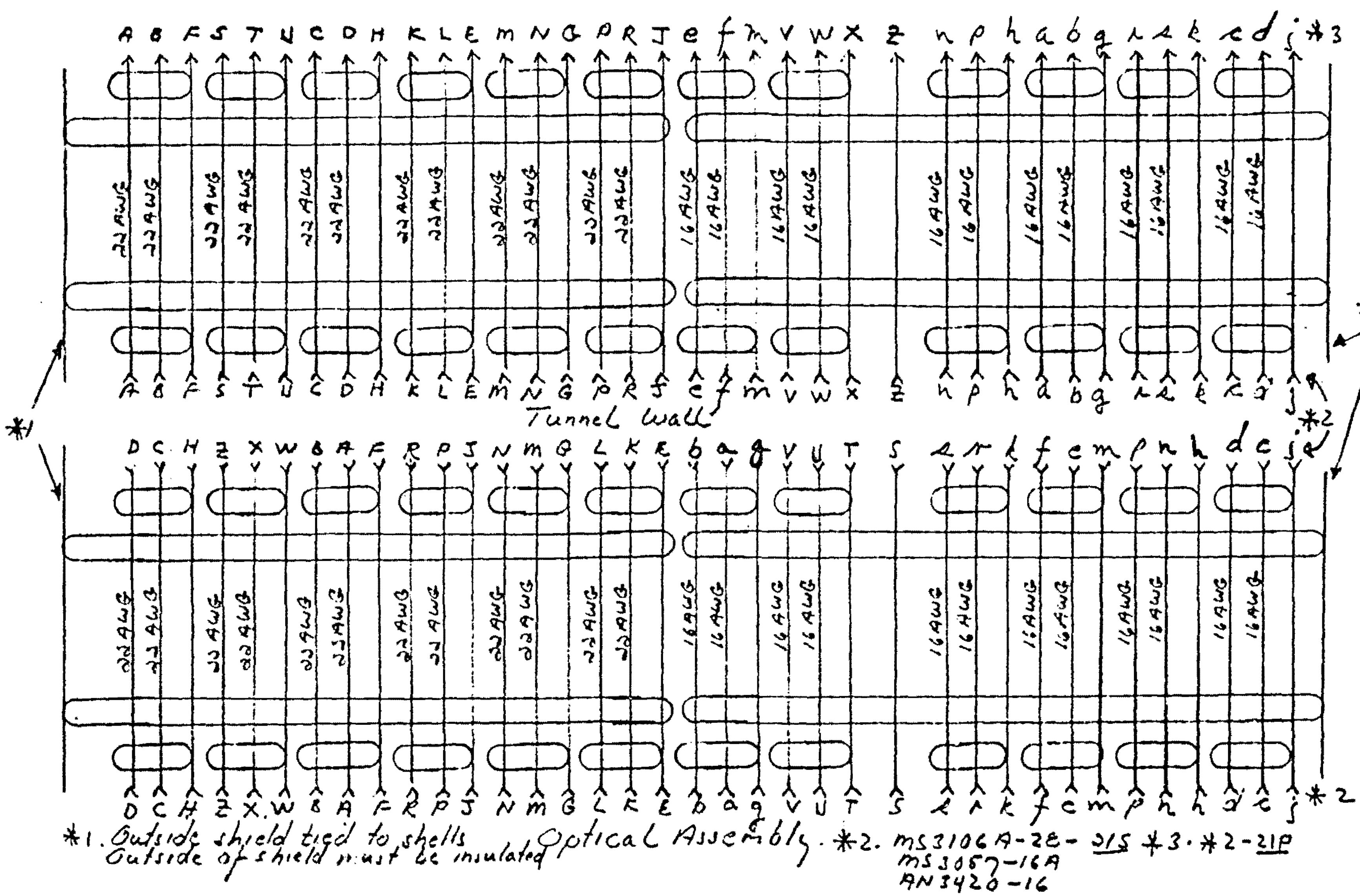


Figure 55: Wiring Diagram for Cable With Connectors J-2

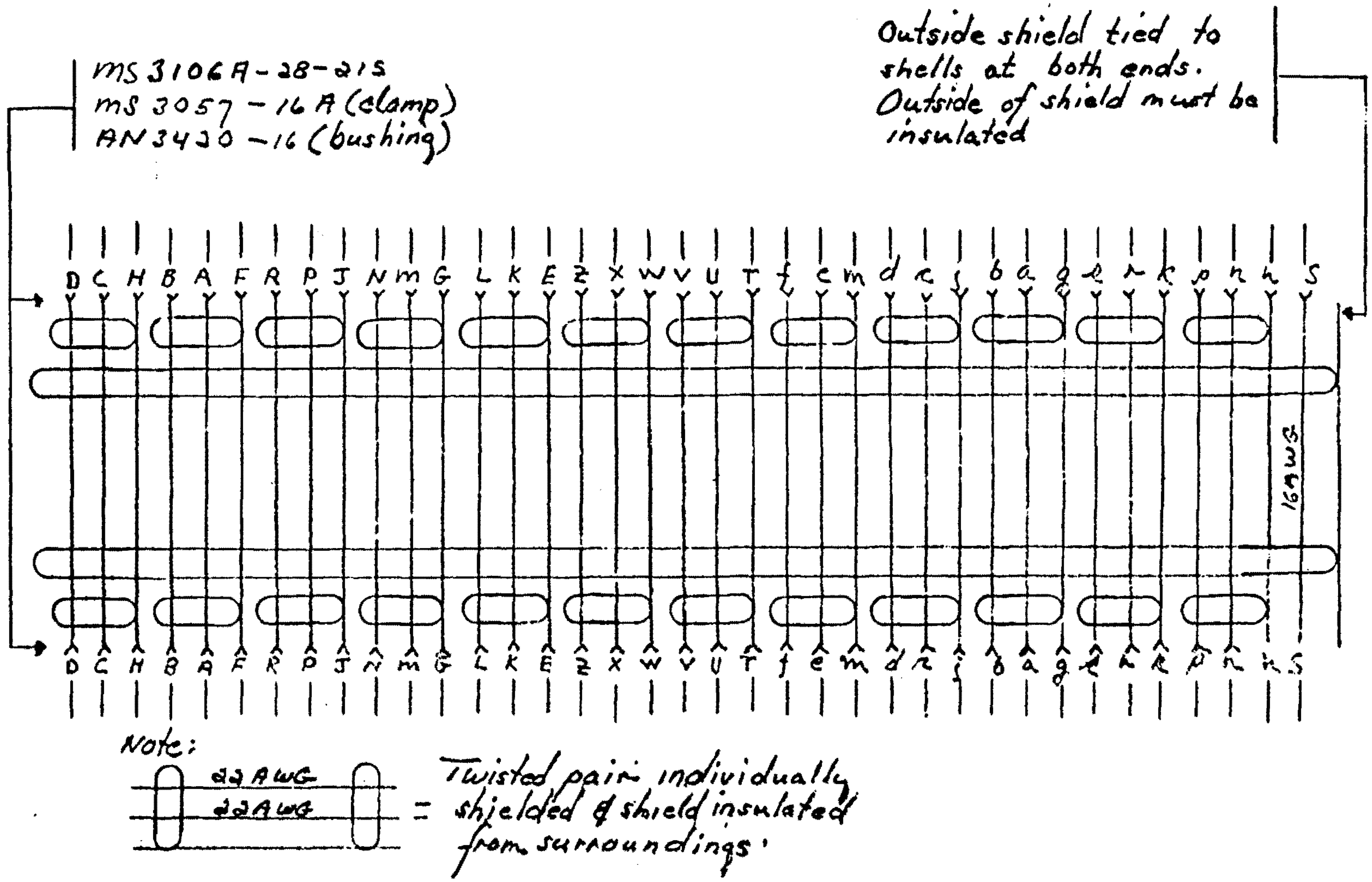
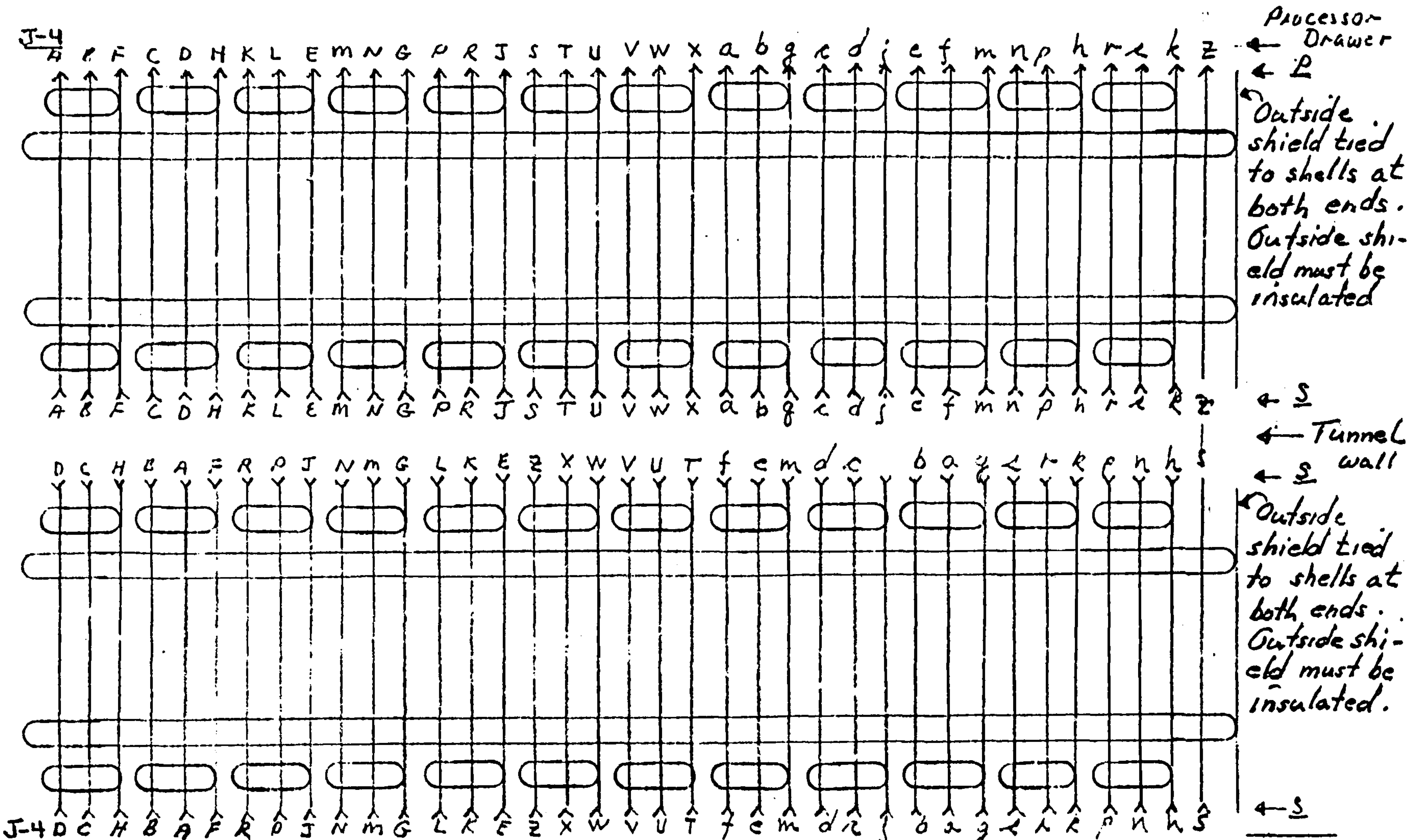


Figure 56: Wiring Diagram for Cable With Connectors J-3



Notes: 22AWG 22AWG Twisted pair individually shielded & shield insulated from surroundings. Connectors: MS3106A-28-21
MS3057-16A (clamp)
AN3420-16 (bushing)

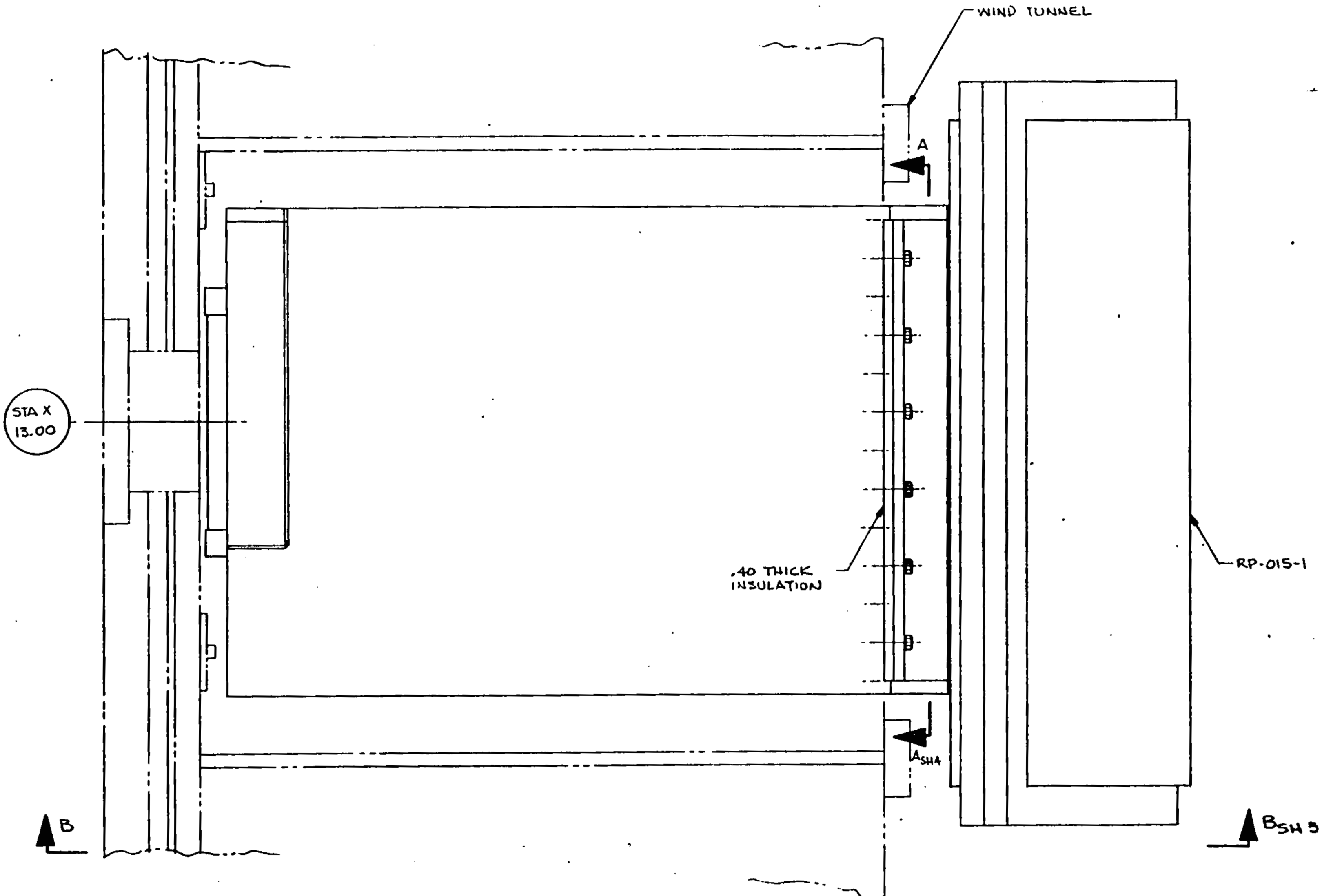
Figure 57: Wiring Diagram for Cable With Connectors J-4

V. MECHANICAL DRAWINGS OF THE OPTICAL SYSTEM

	12	AN960C416	WASHER	
	12	BACB30LJ4-13	BOLT	
	1	RP-015-1	AAMS ASSY	
		-1	AAMS	
	-1	PART NO	NOMENCLATURE	REMARKS

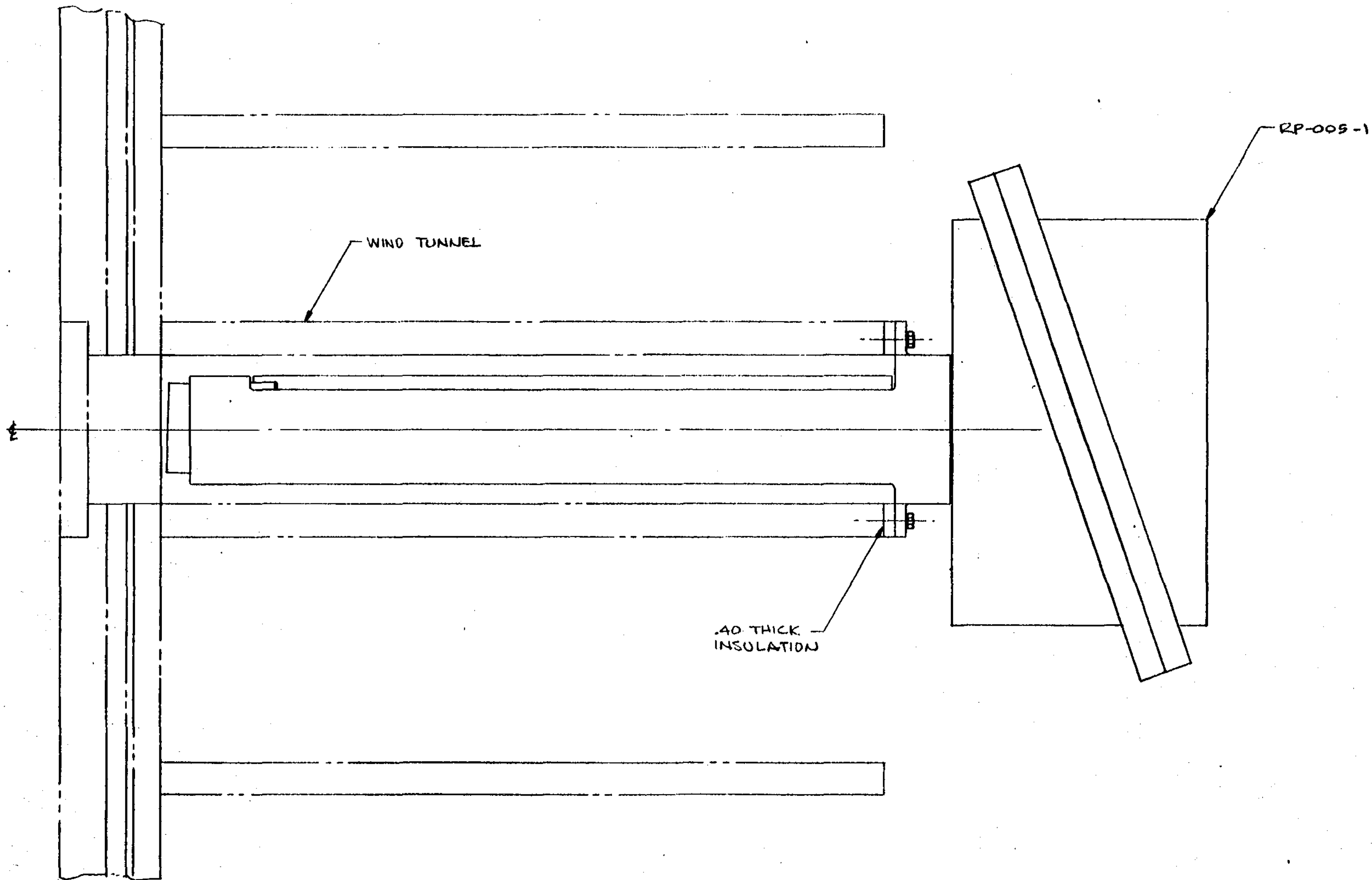
RP-001 SH 1 OF 4
ABSOLUTE ANGLE MEASUREMENT SYSTEM

DWN: TK MATSUMOTO 12/4/81



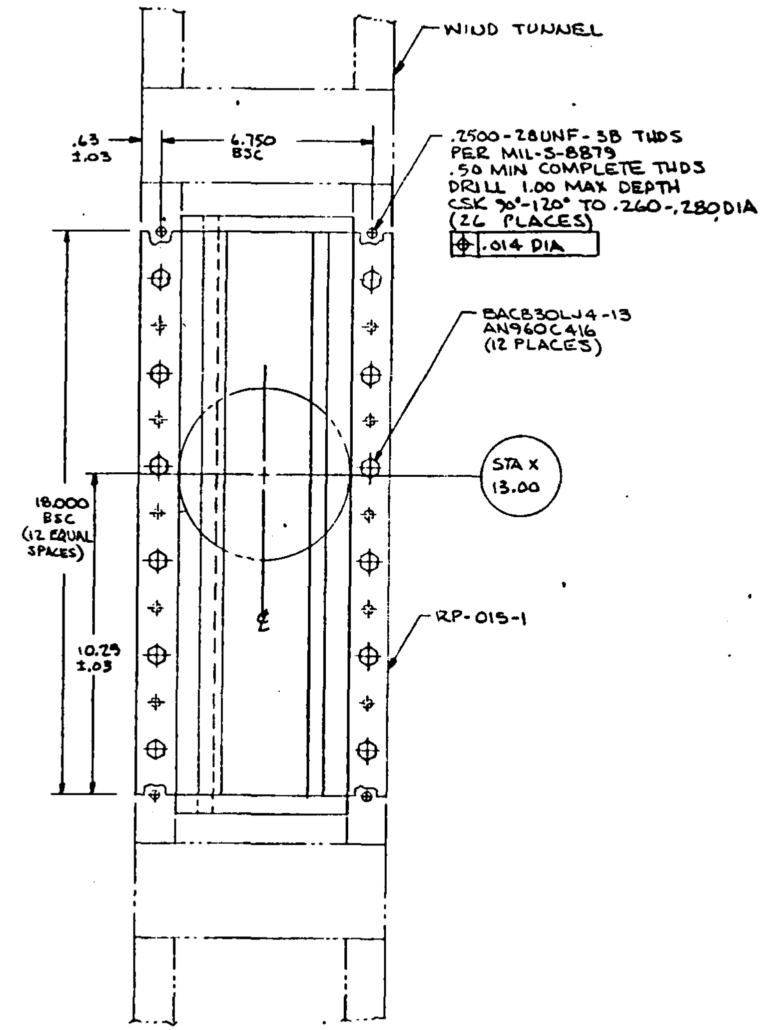
-1 INSTALLATION

RP-001 SH 2
SCALE: 1/4
ABSOLUTE ANGLE MEASUREMENT SYSTEM
DWN: TK MATSUMOTO 12/4/81



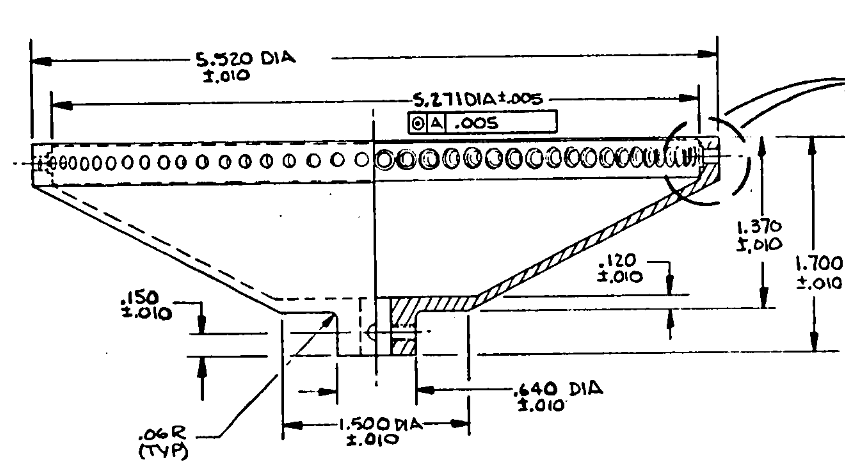
VIEW B-B SH2

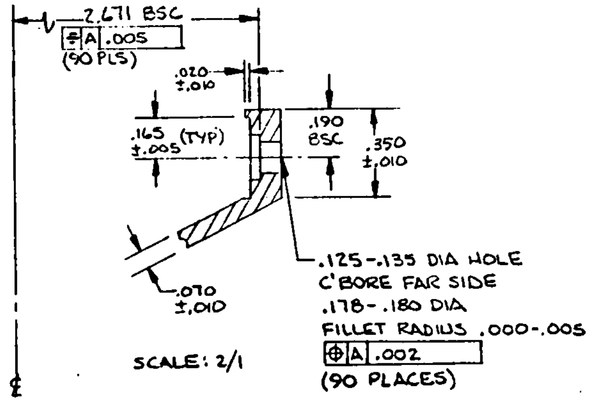
RP-001 SH 3
SCALE: 1/4
ABSOLUTE ANGLE MEASUREMENT SYSTEM
DWN. TK MATSUMOTO 12/4/81



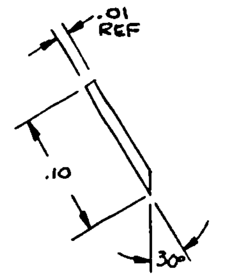
SECTION A-A

RP-001 SH 4
SCALE: 1/4
ABSOLUTE ANGLE MEASUREMENT SYSTEM
DWN: TK MATSUMOTO 12/4/81

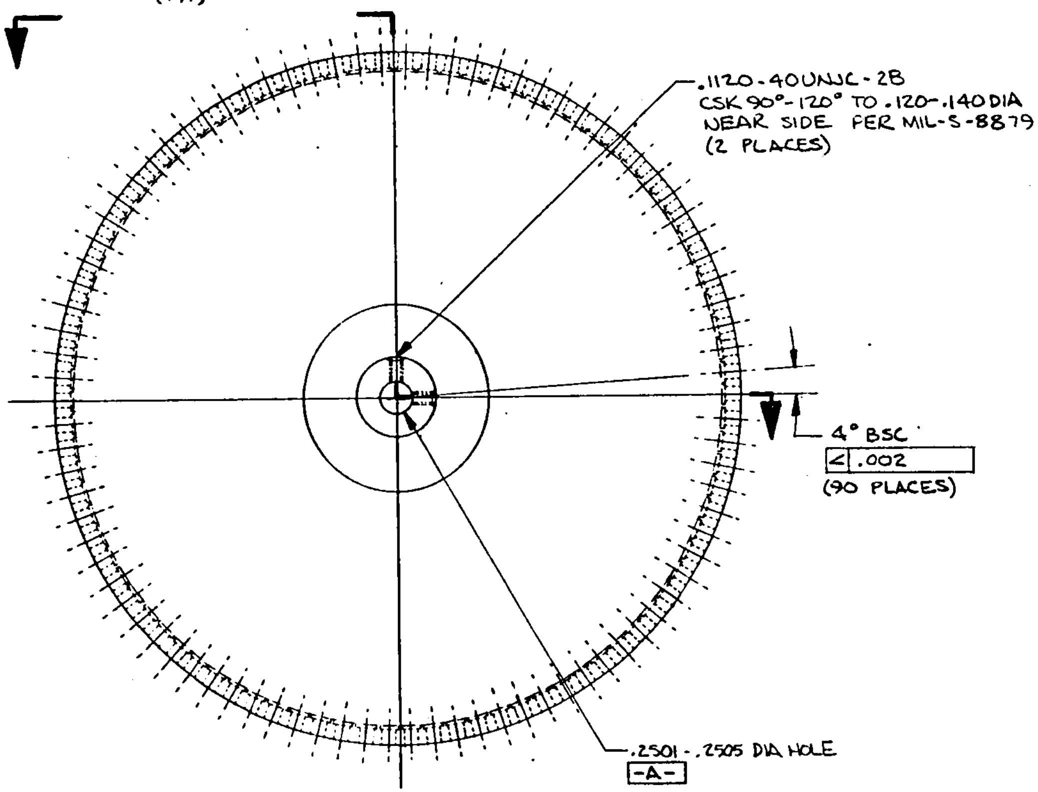




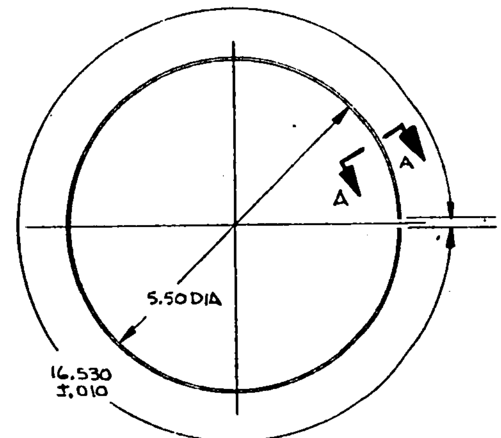
SCALE: 2/1



SECTION A-A
SCALE: 10/1



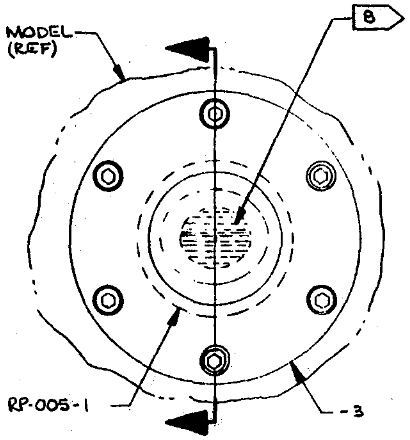
-1 WHEEL [1] [5]

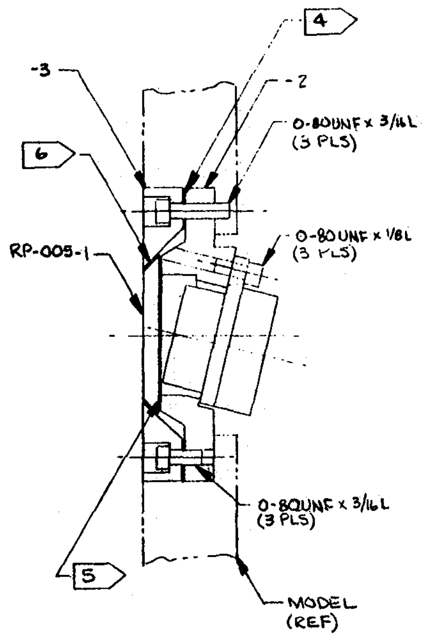


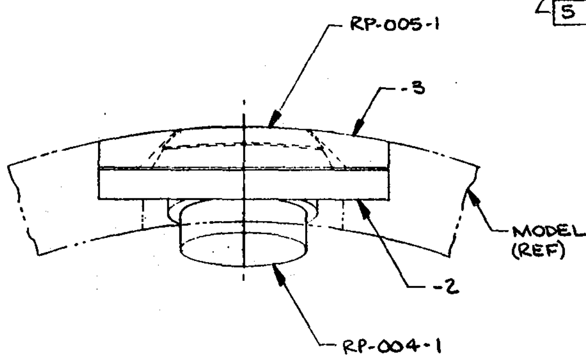
-2 RETAINER [4]
SCALE: 1/2

[5] FINISH PER BAC5884, TYPE II, CLASS 2 COLOR BLACK
[4] 301 CRES .010 THICK PER MIL-S-5059, COMP 301, COND. HARD
3. BREAK ALL SHARP EDGES
2. 63/ ALL MACHINE SURFACES
[1] MATL: 6061-T6 ALUM, 1.75 PLATE PER QQ-A-250/11

RP-002 SH 1 OF 1 SCALE: 1/1
WHEEL
DWN: T.K. MATSUMOTO 8-26-81







-1 REFLECTOR ASSY

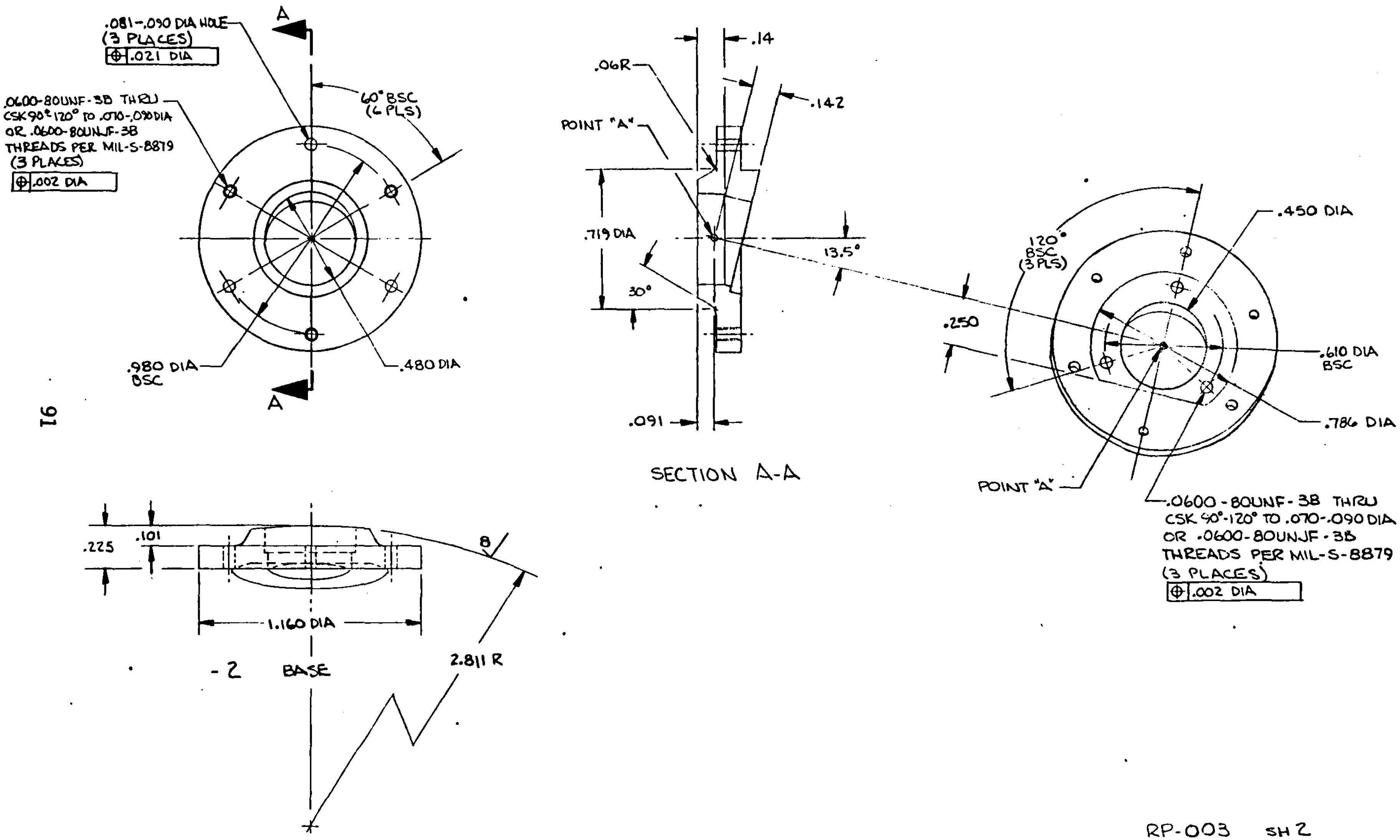
NOTES:

1. FILLET RADIUS .000-.005 (EXCEPT AS NOTED).
2. TOLERANCE:
   .XX ± .01
   .XXX ± .005
   ANGLE ± .5°
3. 63/ ALL MACHINED SURFACES (EXCEPT AS NOTED).

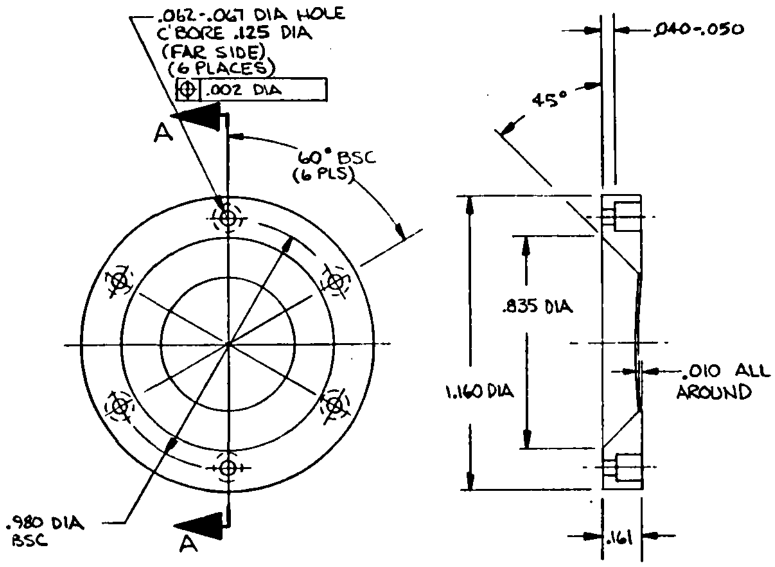
4> SHIM AS REQUIRED.
5> INSTALL GASKET USING PTFE .004 THICK.
6> INSTALL GASKET USING PTFE .004 THICK.
7> MATERIAL: A,B-NITRONIC 40
8> INSTALL RETAINER ASSY WITH HOLOGRAM LINES IN THIS DIRECTION.
9> MATERIAL: CDA #544 FREE CUTTING PHOSPHOR BRONZE

3	3	0-80UNF x 3/16L	CAP SCREW	MATL 304 CRES
6	6	0-80UNF x 1/8L	CAP SCREW	MATL 304 CRES
1	1	RP-005-1	GLASS	
1	1	RP-004-1	RETAINER ASSY	
1		-5	RETAINER	9>
–		-4	REFLECTOR ASSY	
	1	-3	RETAINER	7>
1	1	-2	BASE	9>
	–	-1	REFLECTOR ASSY	
-4	-1	PART NO.	NOMENCLATURE	REMARKS

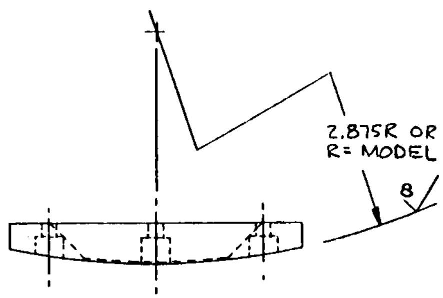
RP-003 SH 1 OF 4
REFLECTOR ASSY-
SCALE: 2/1
DWN: TK. MATSUMOTO 9-2-81



RP-003 SH 2
REFLECTOR ASSY-
SCALE: 2/1
DWN: T.K. MATSUMOTO 9-2-81

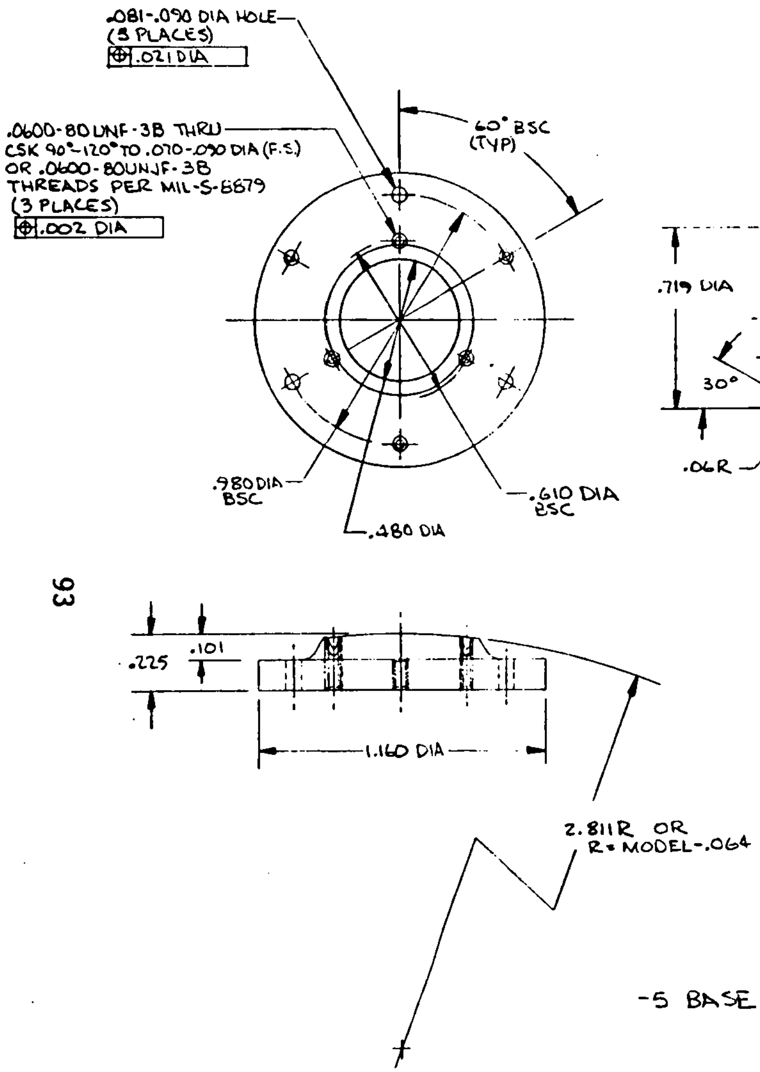


SECTION A-A

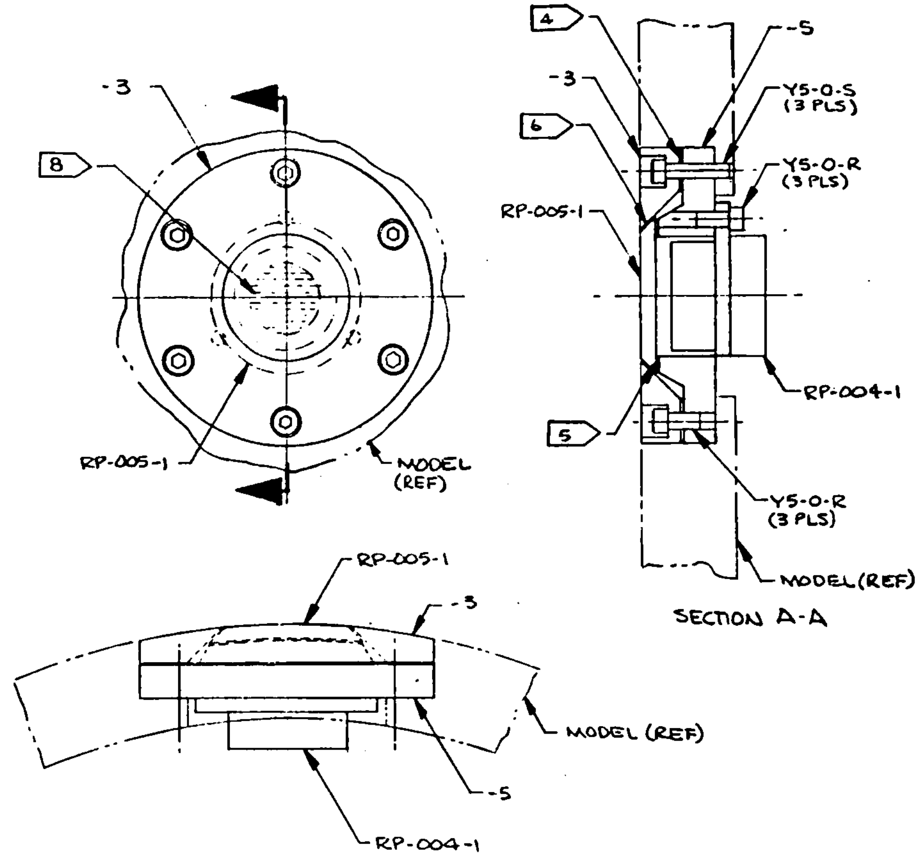


-3 RETAINER

RP-003 SH 3
REFLECTOR ASSY-
SCALE: 2/1
DWN. TK. MATSUMOTO 9-2-81

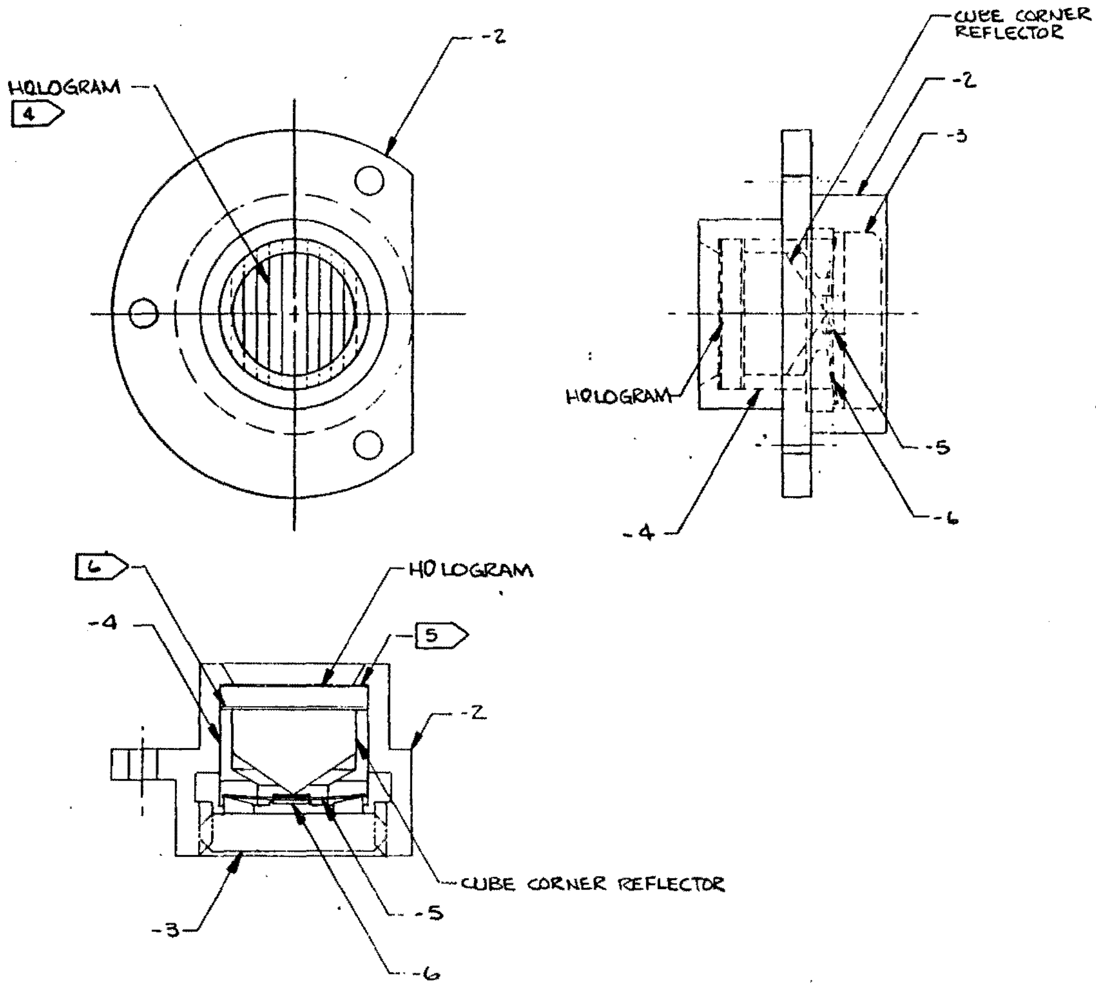


-5 BASE



-4 REFLECTOR ASSY

RP-003 SH 4
REFLECTOR ASSY-
SCALE: 2/1
DWN: T.K. MATSUMOTO 9-8-81



-1 RETAINER ASSY

NOTES:

1. FILLET RADIUS .000-.005 (EXCEPT AS NOTED).
2. TOLERANCE:
   .XX ±.01
   .XXX ±.005
   ANGLE ±.5°
3. 63/ ALL MACHINED SURFACES (EXCEPT AS NOTED).

4 INSTALL HOLOGRAM LINES IN THIS DIRECTION.

5 BOND HOLOGRAM TO -2

6 INSTALL GASKET USING PTFE .050 THICK.

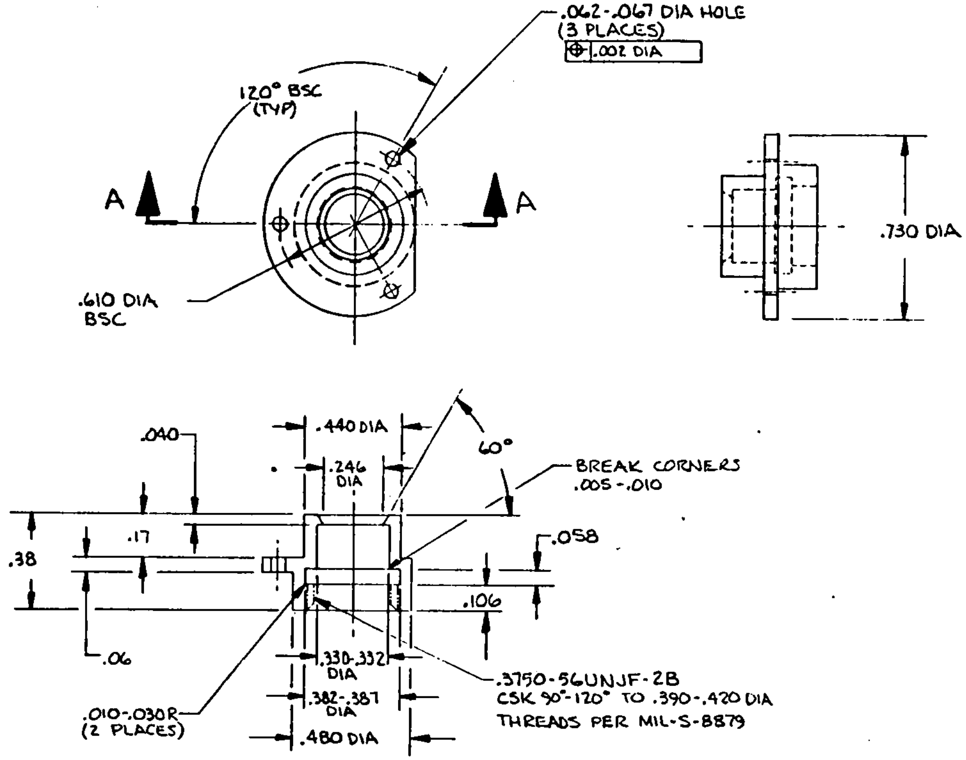
7 BOND GASKET TO -6

8 MATERIAL: CDA #544 FREE CUTTING PHOSPHOR BRONZE

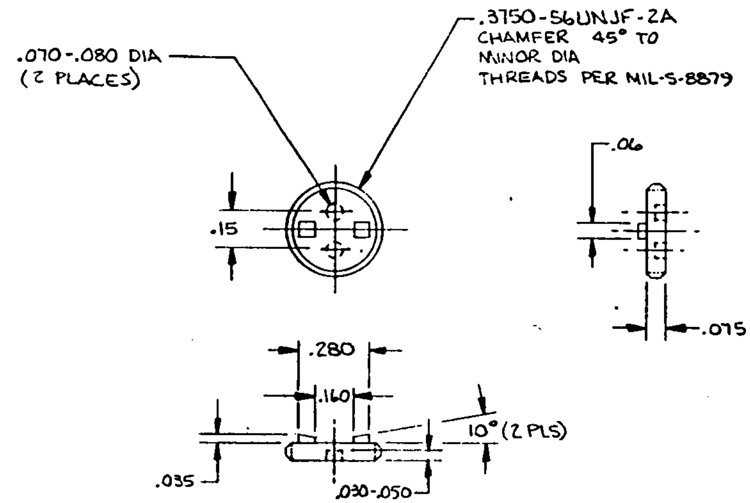
9 MATERIAL: INCONEL X-750

	1		HOLOGRAM	
1	1	-6	SPRING	9
—	1	-5	SPRING ASSY	
	1	-4	CYLINDER	8
	1	-3	PLUG	8
	1	-2	HOUSING	8
	—	-1	RETAINER ASSY	
-5	-1	PART NO	NOMENCLATURE	REMARKS

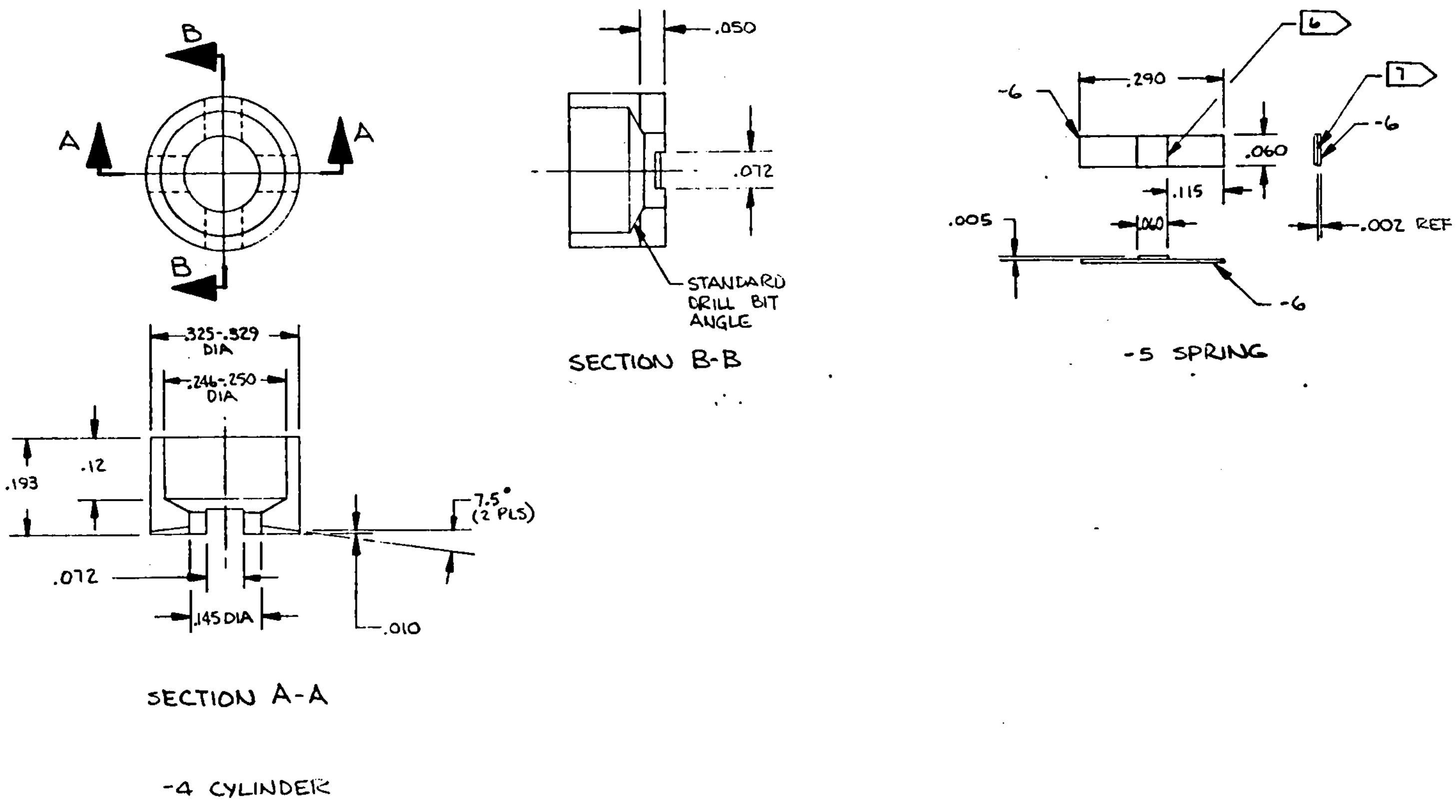
RP-004 SH 1 OF 3
RETAINER ASSY-
SCALE: 4/1
DWN: TK MATSUMOTO 9-3-81



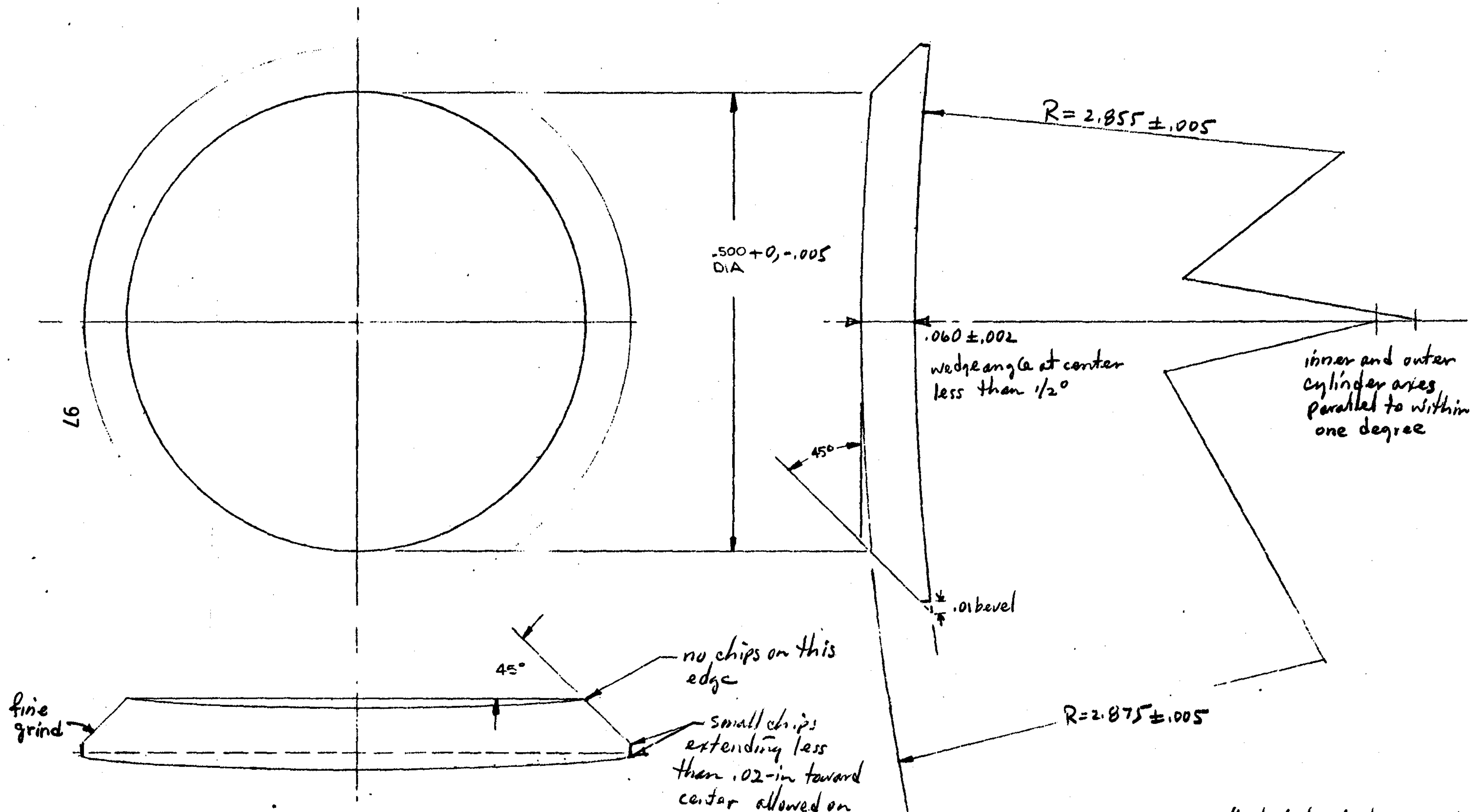
-2 HOUSING



RP-004 SH 2
RETAINER ASSY
SCALE: 2/1
DWN: T.K. MATSUMOTO 9-3-81

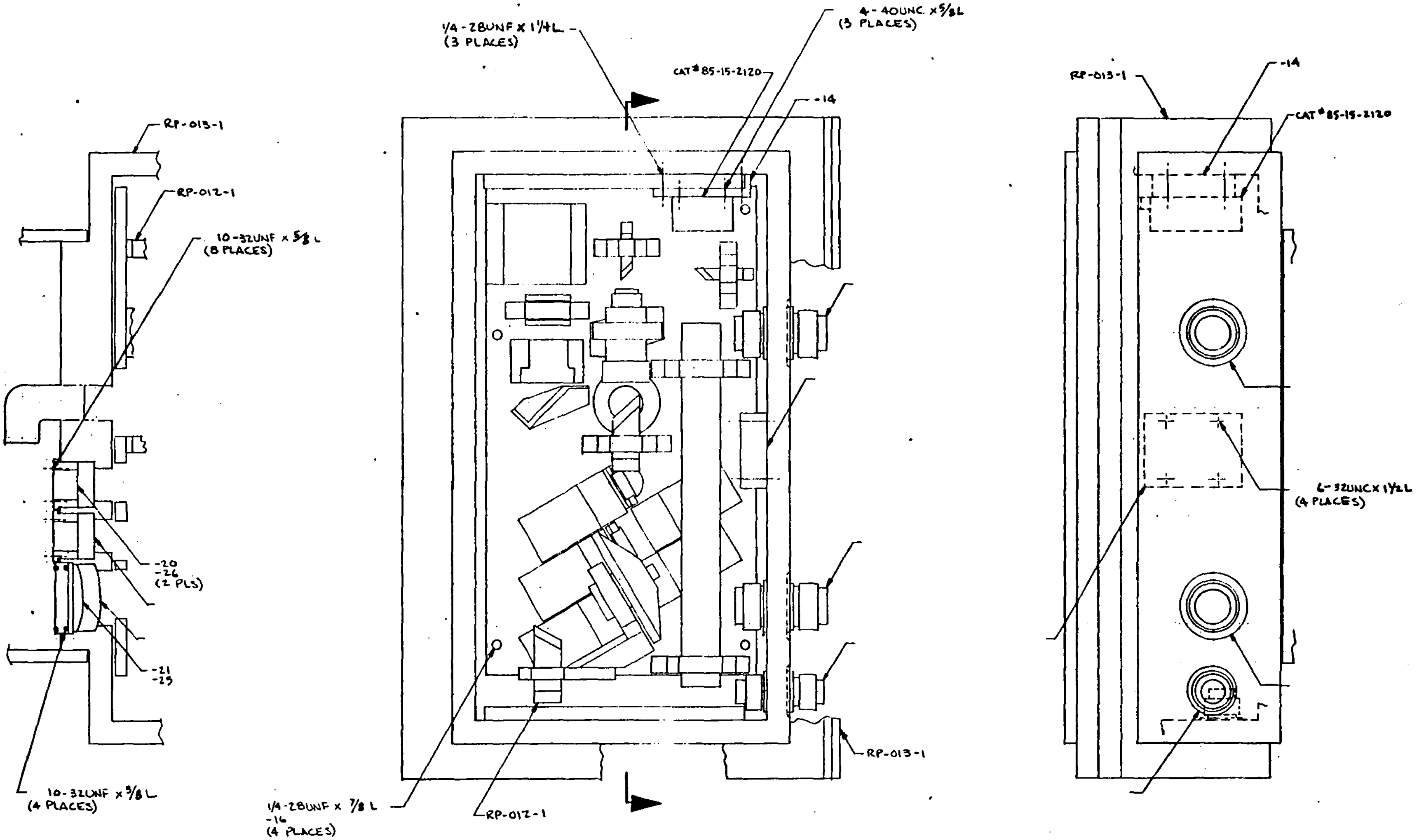


RP-004 SH 3
RETAINER ASSY.
SCALE: 4/1
DWN: TK. MATSUMOTO 9-3-81



97

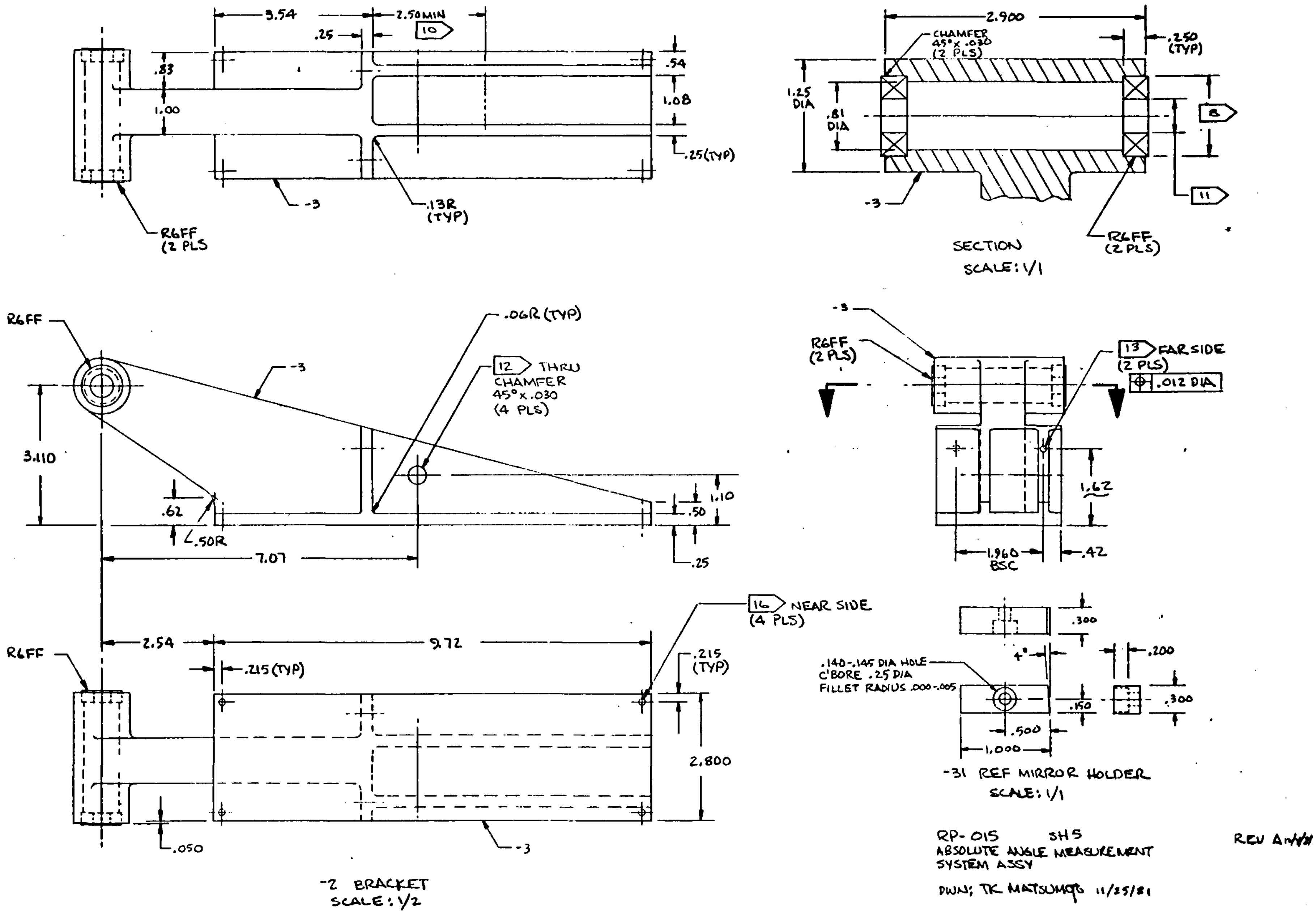
RP-005 cylindrical window
GLASS fused silica, optical polish
SCALE: 10/1
DWN: TK MATSUMOTO 9-8-81, Rev 8-23-82 CRP



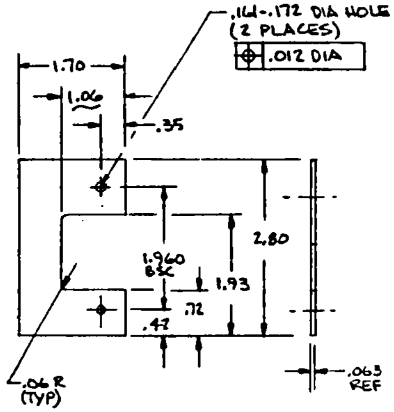
RP- 015 SH 4
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY

DWN: TK MATSUMOTO 11/25/81

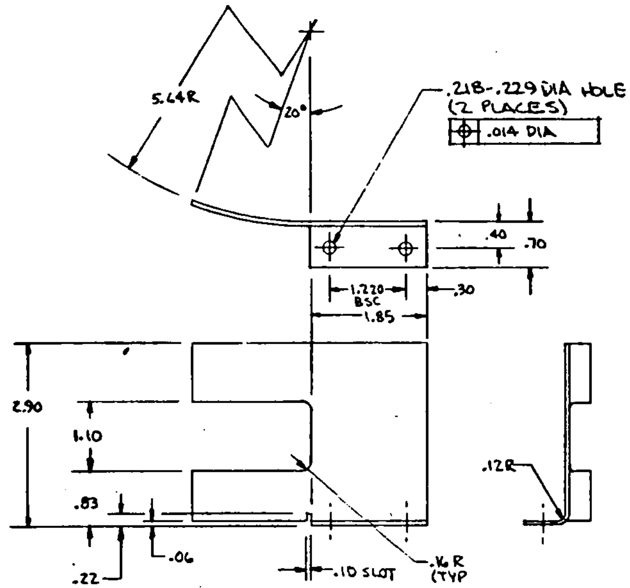
REV A 12/8/81
REV B 1/25/82



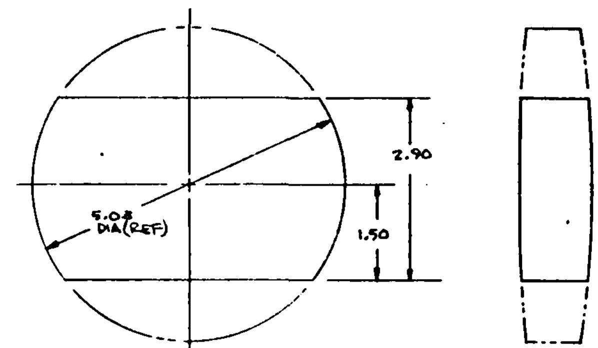
3.54
2.50 MIN
10
.25
.83
.54
1.00
1.08
.25(TYP)
-3
.13R (TYP)
R6FF (2 PLS)
2.900
CHAMFER 45° x .030 (2 PLS)
.250 (TYP)
1.25 DIA
.81 DIA
B
11
R6FF (2 PLS)
SECTION
SCALE: 1/1
R6FF
.06R (TYP)
12 THRU CHAMFER 45° x .030 (4 PLS)
3.110
.62
.50R
1.10
.50
7.07
.25
R6FF (2 PLS)
13 FAR SIDE (2 PLS)
.012 DIA
1.62
1.960 BSC
.42
16 NEAR SIDE (4 PLS)
2.54
9.72
.215 (TYP)
2.800
.050
-2 BRACKET
SCALE: 1/2
.300
4°
.200
.140-.145 DIA HOLE
C'BORE .25 DIA
FILLET RADIUS .000-.005
.150
.300
.500
1.000
-31 REF MIRROR HOLDER
SCALE: 1/1
RP-015 SH 5
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY
DWN: TK MATSUMOTO 11/25/81
REV A



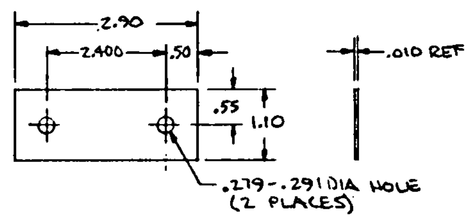
-5 BAFFLE



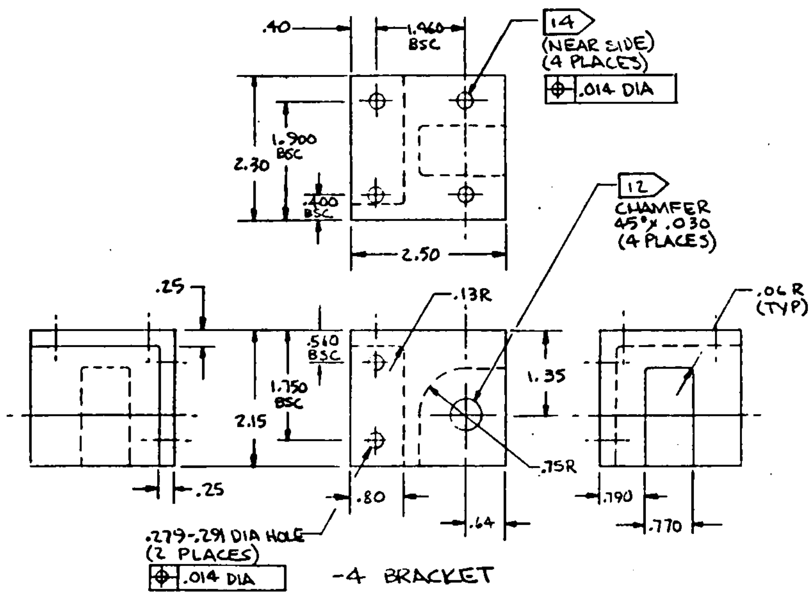
-6 BAFFLE



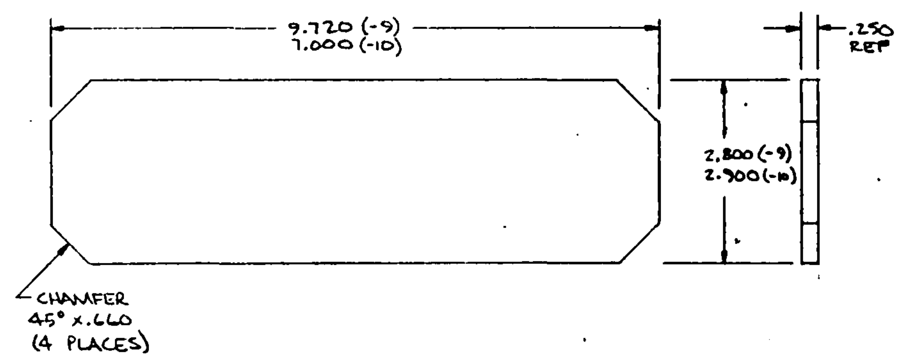
-7 LENS



-8 SHIM



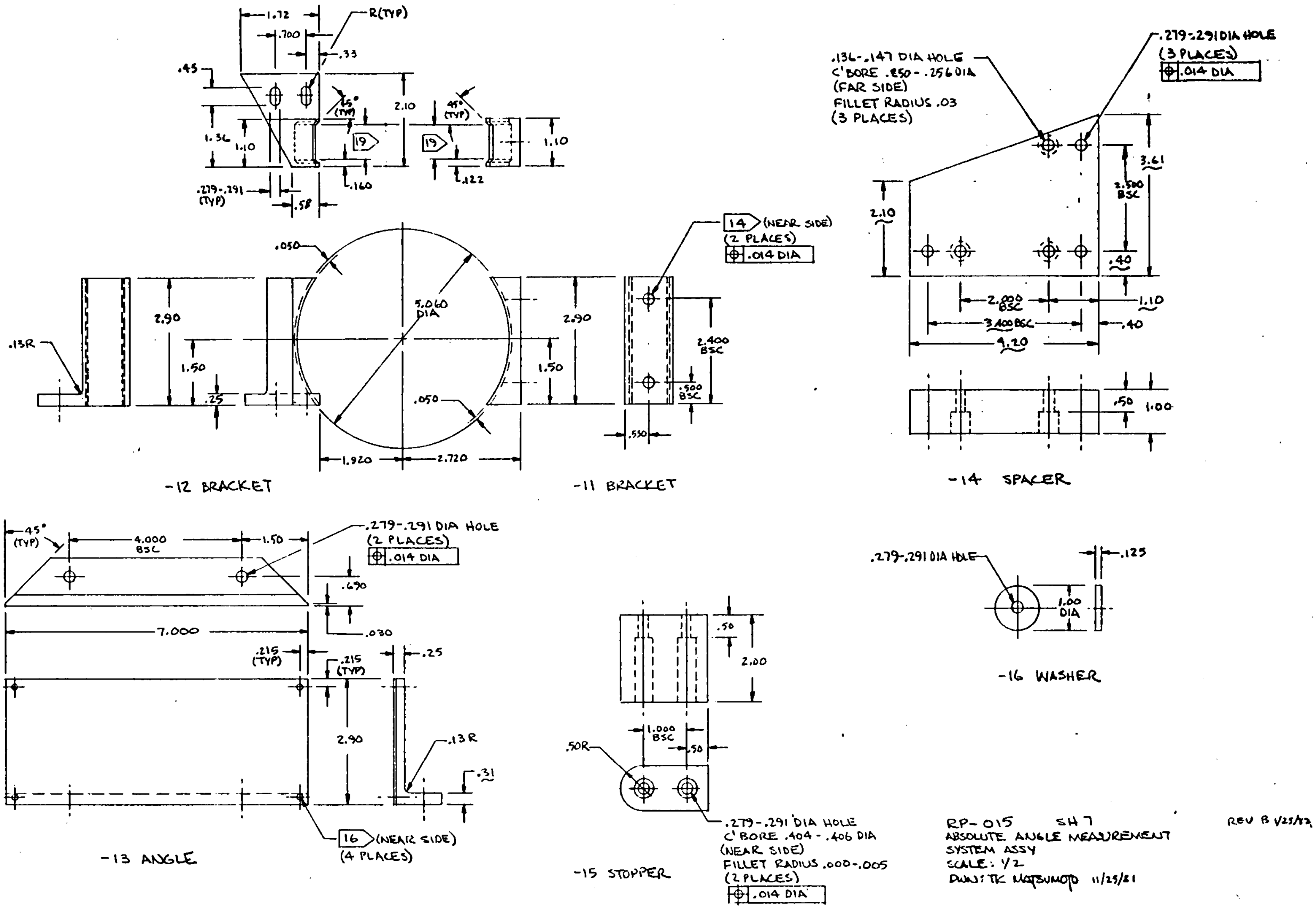
-4 BRACKET

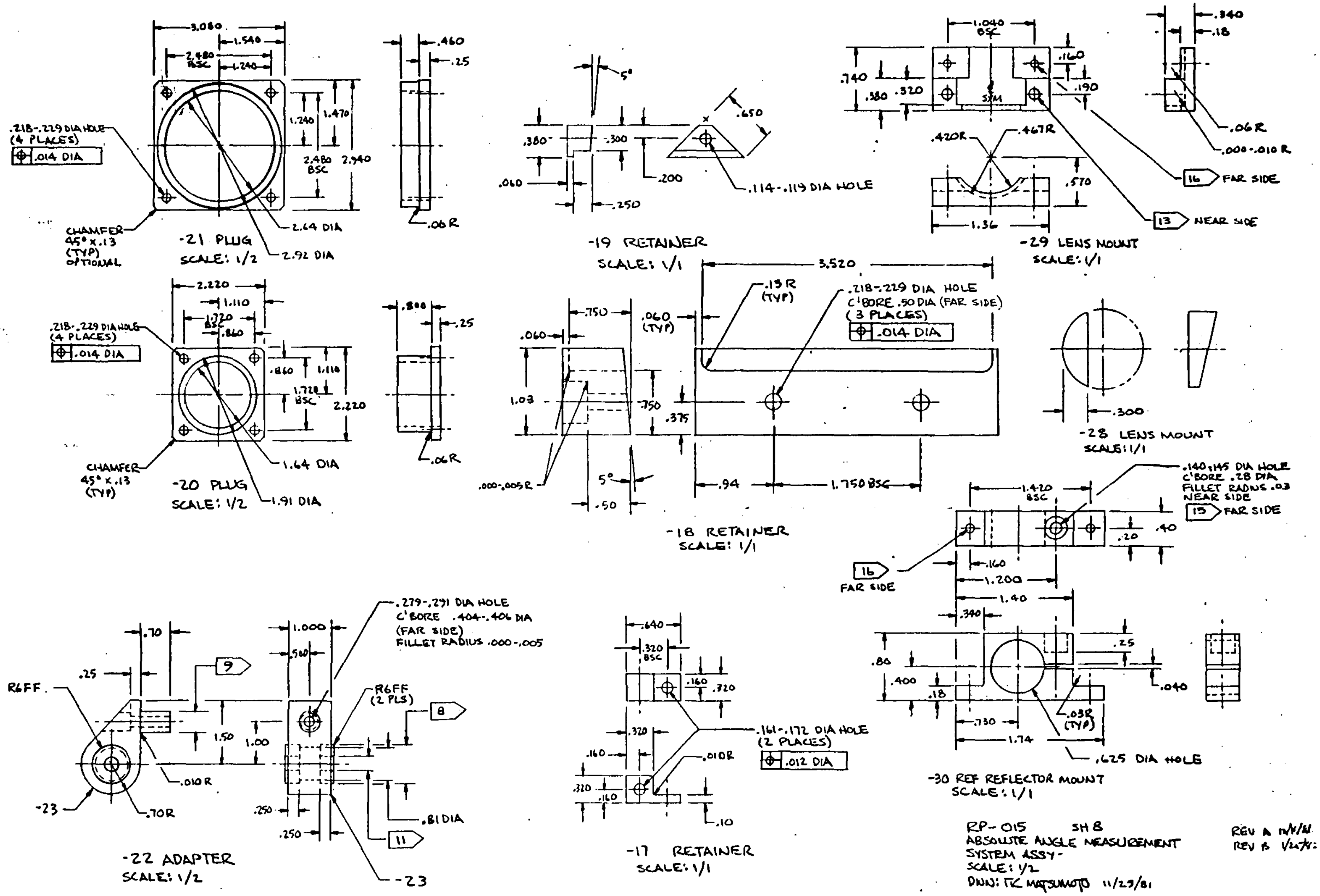


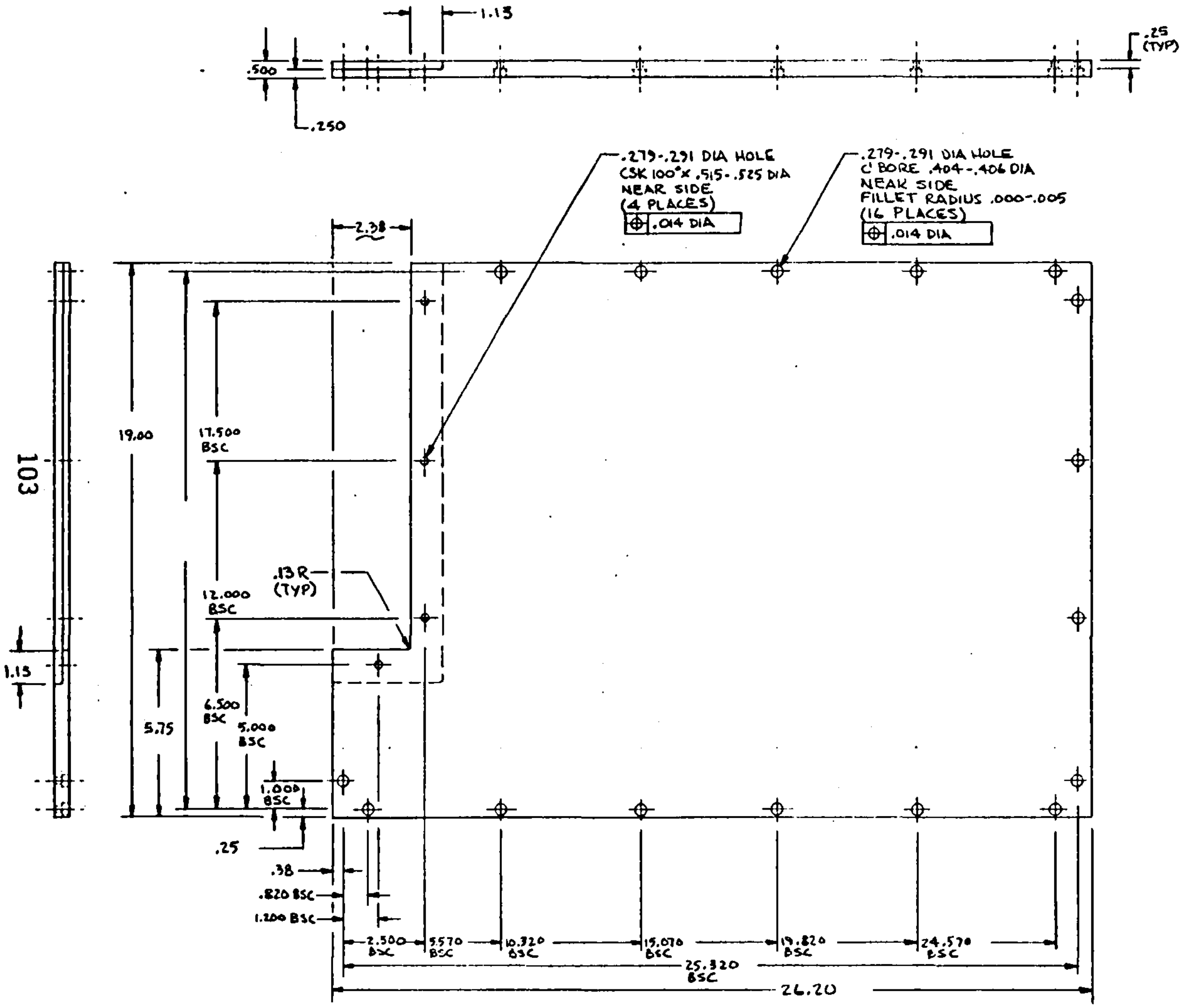
-9 & -10 MIRROR

RP-015 SH 6
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY
SCALE: 1/2
DWN: TK MATSUMOTO 11/25/81

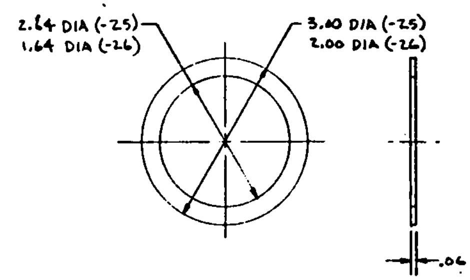
REV B 1/25/82


R(TYP)
.279-.291 DIA HOLE (3 PLACES) .014 DIA
.136-.147 DIA HOLE C'BORE .250-.256 DIA (FAR SIDE) FILLET RADIUS .03 (3 PLACES)
14 (NEAR SIDE) (2 PLACES) .014 DIA
5.060 DIA
-12 BRACKET
-11 BRACKET
-14 SPACER
.279-.291 DIA HOLE (2 PLACES) .014 DIA
.279-.291 DIA HOLE
-16 WASHER
16 (NEAR SIDE) (4 PLACES)
-13 ANGLE
.279-.291 DIA HOLE C'BORE .404-.406 DIA (NEAR SIDE) FILLET RADIUS .000-.005 (2 PLACES) .014 DIA
-15 STOPPER
RP-015 SH 7
ABSOLUTE ANGLE MEASUREMENT SYSTEM ASSY
SCALE: 1/2
DWN: TK MATSUMOTO 11/25/81
REV B 1/25/82

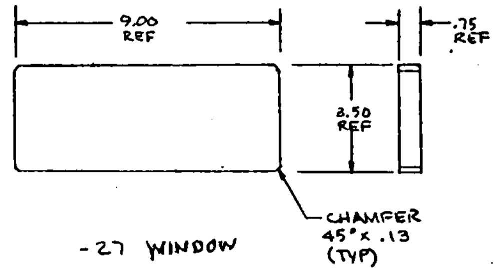

.218-.229 DIA HOLE (4 PLACES)
.014 DIA
CHAMFER 45° x .13 (TYP) OPTIONAL
-21 PLUG
SCALE: 1/2
2.64 DIA
2.92 DIA
.06R
-19 RETAINER
SCALE: 1/1
.114-.119 DIA HOLE
-29 LENS MOUNT
SCALE: 1/1
.06R
.000-.010 R
16 FAR SIDE
13 NEAR SIDE
.218-.229 DIA HOLE (4 PLACES)
.014 DIA
CHAMFER 45° x .13 (TYP)
-20 PLUG
SCALE: 1/2
1.64 DIA
1.91 DIA
.06R
.000-.005R
-18 RETAINER
SCALE: 1/1
.15 R (TYP)
.218-.229 DIA HOLE C'BORE .50 DIA (FAR SIDE) (3 PLACES)
.014 DIA
1.750 BSC
-28 LENS MOUNT
SCALE: 1/1
.140-.145 DIA HOLE C'BORE .28 DIA FILLET RADIUS .03 NEAR SIDE
15 FAR SIDE
16 FAR SIDE
.279-.291 DIA HOLE C'BORE .404-.406 DIA (FAR SIDE) FILLET RADIUS .000-.005
R6FF
R6FF (2 PLS)
.010R
.70R
.81 DIA
-23
-22 ADAPTER
SCALE: 1/2
.161-.172 DIA HOLE (2 PLACES)
.012 DIA
.010R
-17 RETAINER
SCALE: 1/1
.03R (TYP)
.625 DIA HOLE
-30 REF REFLECTOR MOUNT
SCALE: 1/1
RP-015 SH 8
ABSOLUTE ANGLE MEASUREMENT SYSTEM ASSY-
SCALE: 1/2
DWN: TK MATSUMOTO 11/25/81
REV A
REV B



-24 COVER
SCALE: 1/4



-25 & -26 GASKET
SCALE: 1/2

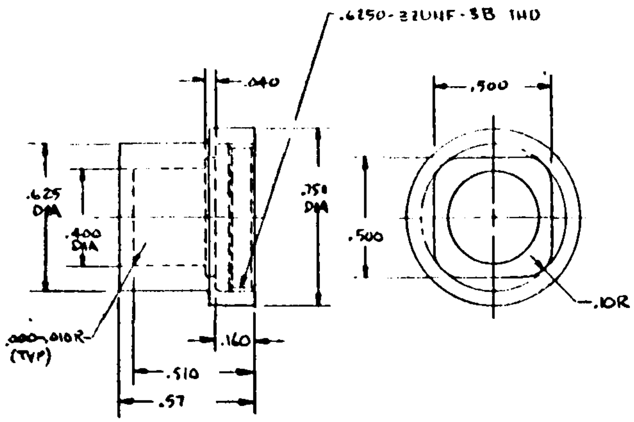


-27 WINDOW

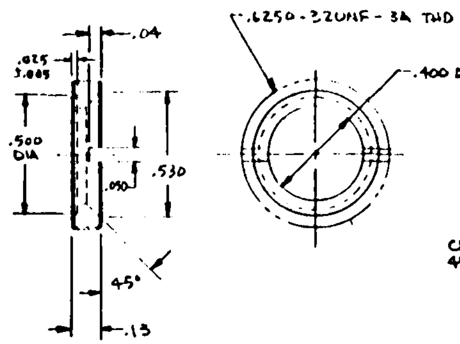
103

RP-015 SH 9
ABSOLUTE ANGLE MEASUREMENT SYSTEM ASSY
DWN: TK MATSUMOTO 11/25/81

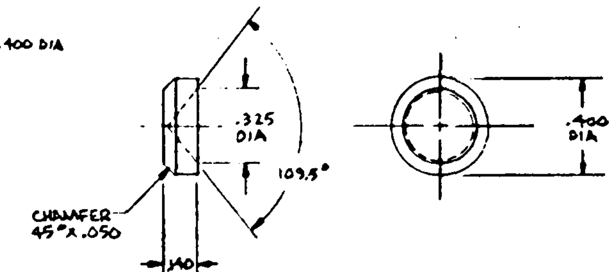
REV B 1/25/82



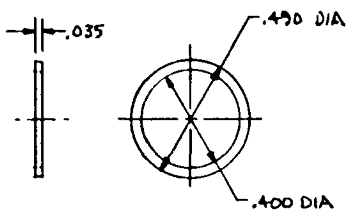
-2 HOUSING



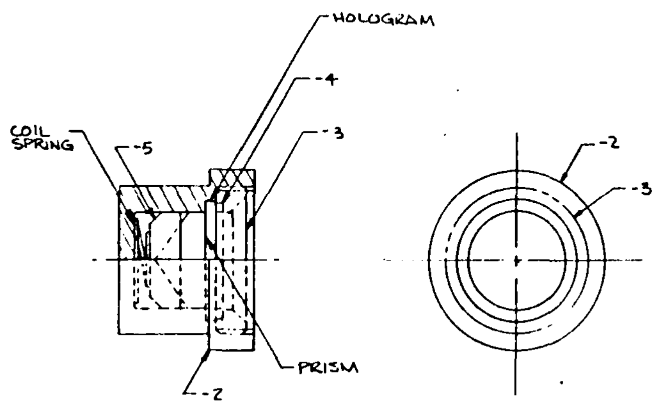
-3 RETAINER



-5 PRISM HOLDER



-4 GASKET



-1 DETECTOR ASSY

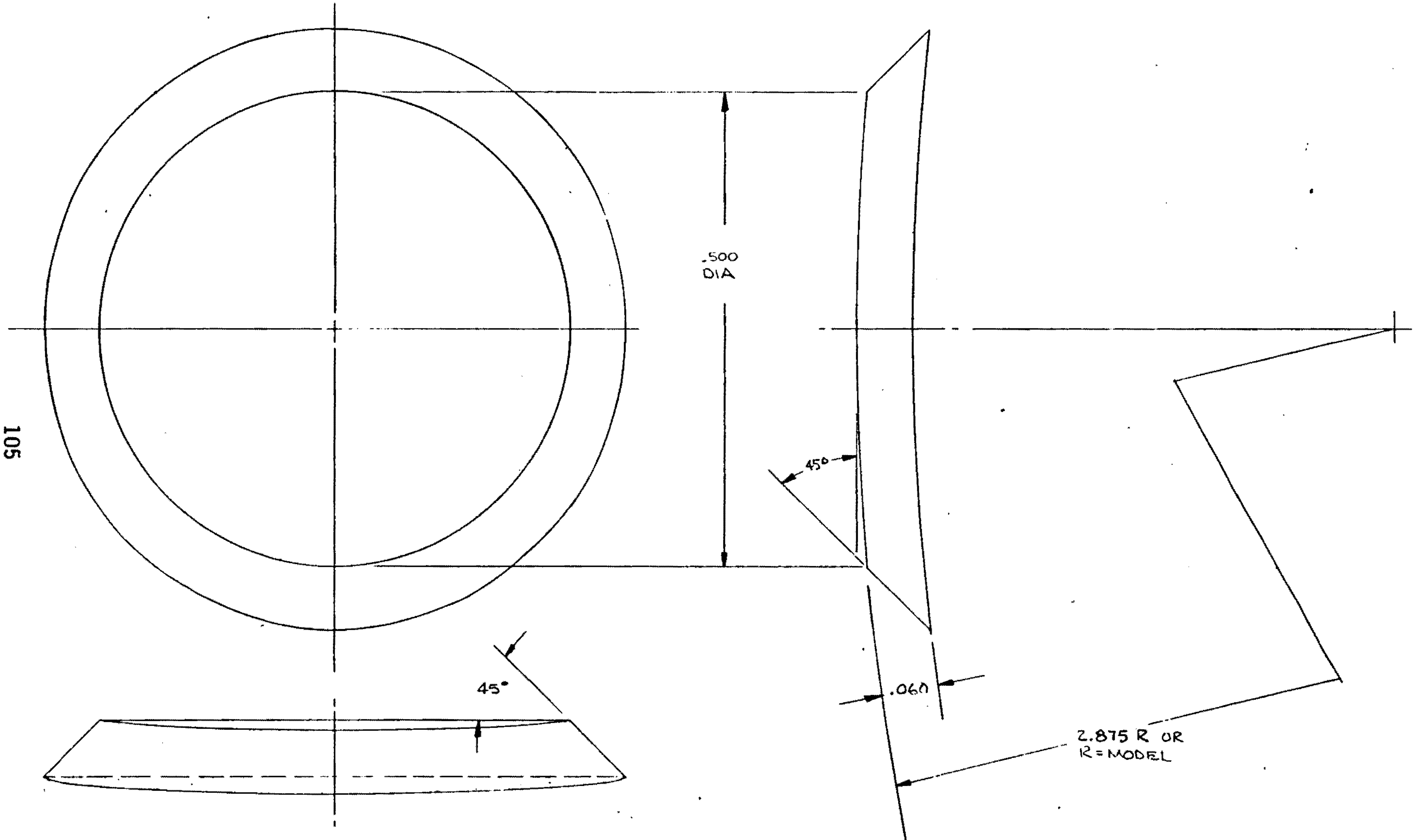
NOTES

1. TOLERANCES
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ ALL MACHINED SURFACES
3. MATERIAL: 2024-T4 ALUMINUM
4. FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK
5. BREAK ALL SHARP EDGES.
6. MAKE FROM PTFE

	1		HOLOGRAM	
	1		COIL SPRING	
	1		PRISM	
	1	-5	PRISM HOLDER	6
	1	-4	GASKET	6
	1	-3	RETAINER	3 4
	1	-2	HOUSING	3 4
	—	-1	REF DETECTOR ASSY	
	-1	PART NO.	NOMENCLATURE	REMARKS

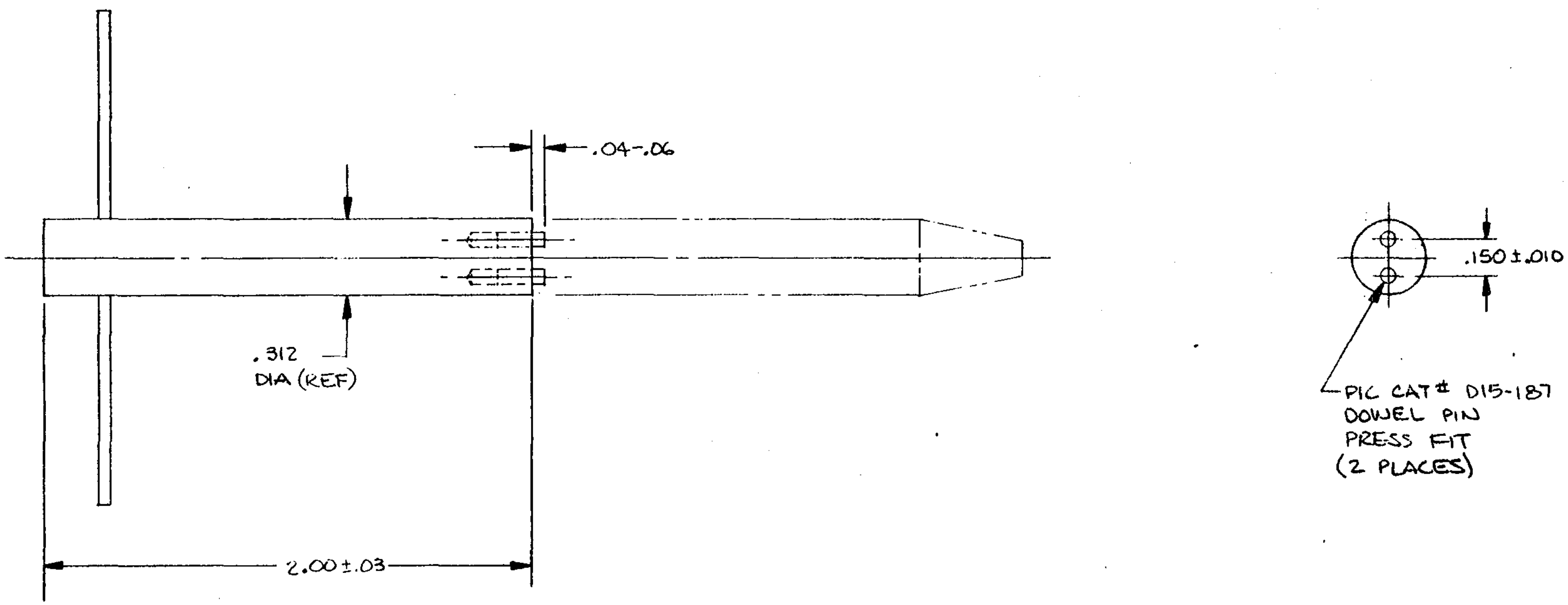
RP-016 SH 1 OF 1
REF DETECTOR ASSY

DWN: TK MATSUMOTO 12-4-81



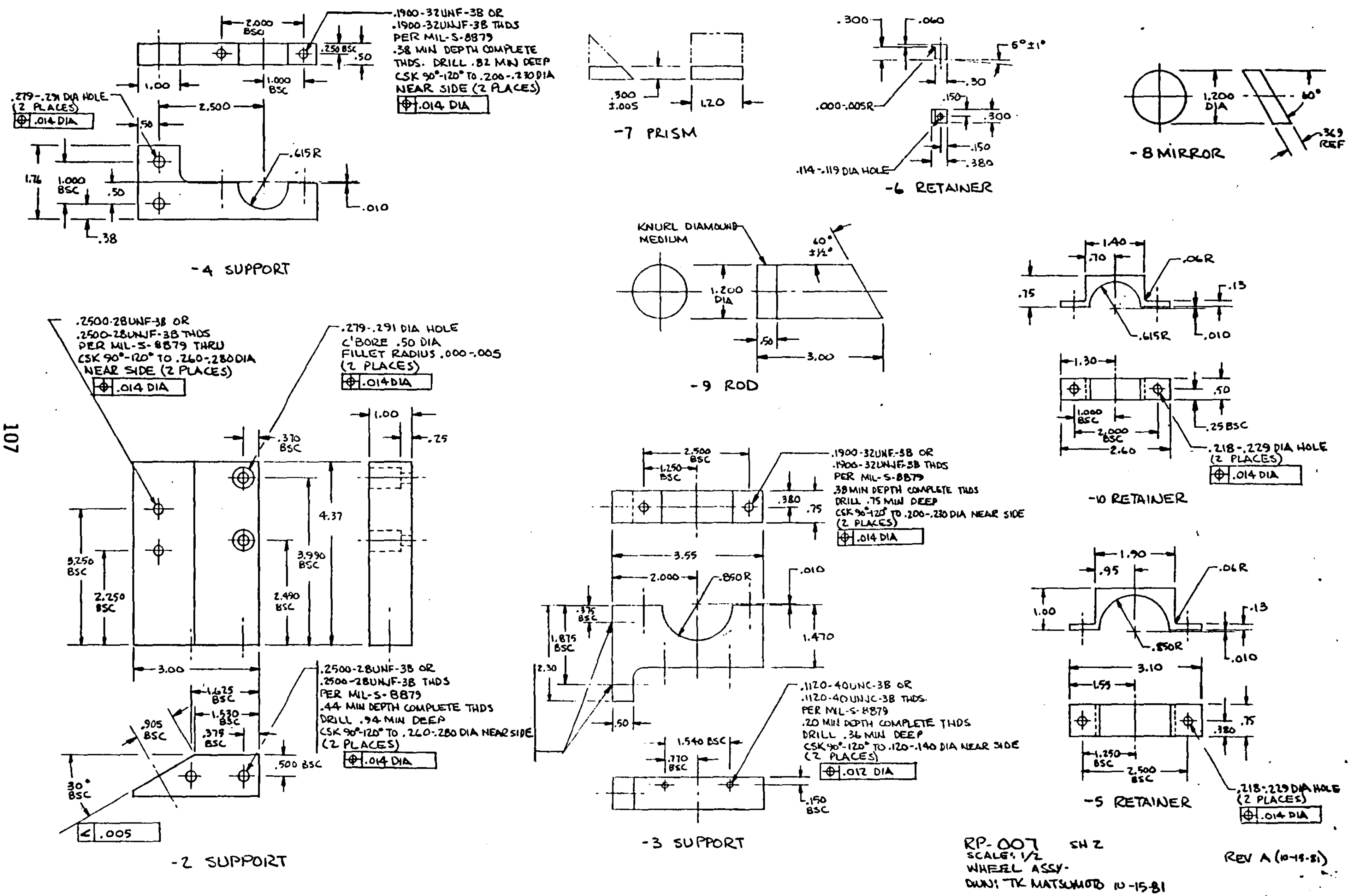
RP-005
GLASS
SCALE: 10/1
DWN: TK MATSUMOTO 9-8-81

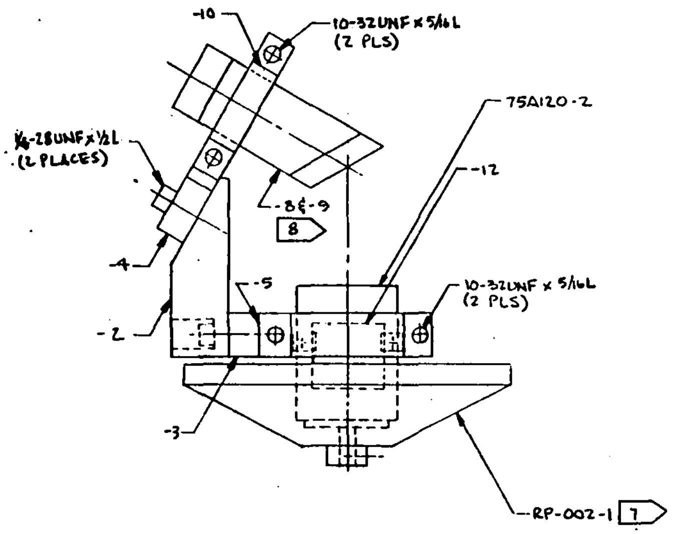
105

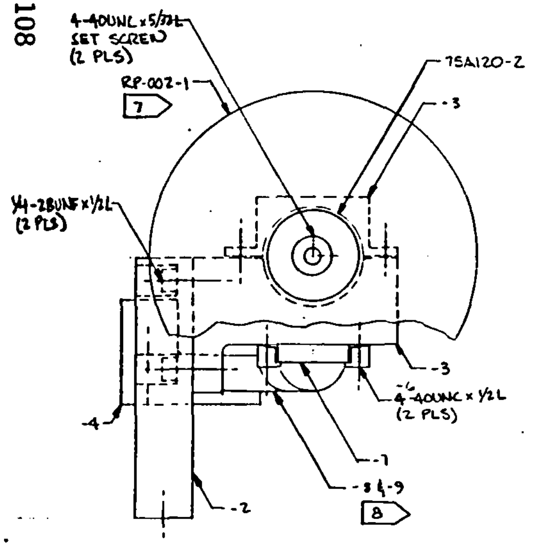


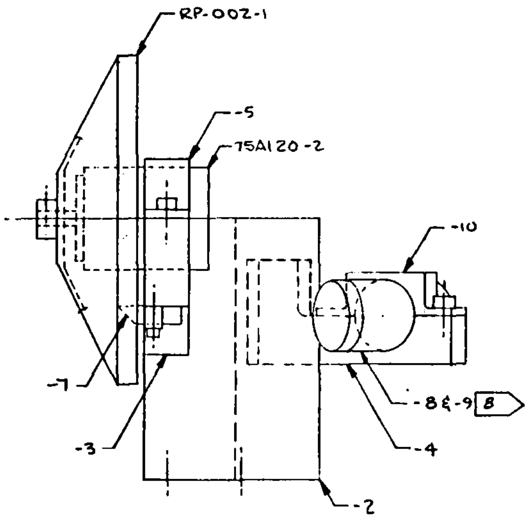
MAKE FROM UT-7036-35
PIN BLANK-SLIDING HANDLE

RP-006
TOOL
SCALE: 2/1
DWN: TK MATSUMOTO 9-8-81


-4 SUPPORT
.1900-32UNF-3B OR .1900-32UNJF-3B THDS PER MIL-S-8879 .38 MIN DEPTH COMPLETE THDS. DRILL .82 MIN DEEP CSK 90°-120° TO .200-.230 DIA NEAR SIDE (2 PLACES)
.014 DIA
.279-.291 DIA HOLE (2 PLACES)
.014 DIA
2.000 BSC
1.000 BSC
.250 BSC
.50
1.00
2.500
.615R
1.76
1.000 BSC
.50
.38
.010
-7 PRISM
.300 ±.005
1.20
-6 RETAINER
.300
.060
6°±1°
.30
.000-.005R
.150
.300
.150
.380
.114-.119 DIA HOLE
-8 MIRROR
1.200 DIA
60°
.369 REF
-9 ROD
KNURL DIAMOND MEDIUM
60° ±1/2°
1.200 DIA
.50
3.00
-10 RETAINER
1.40
.70
.06R
.13
.75
.615R
.010
1.30
.50
1.000 BSC
2.000 BSC
2.60
.25 BSC
.218-.229 DIA HOLE (2 PLACES)
.014 DIA
-2 SUPPORT
.2500-28UNF-3B OR .2500-28UNJF-3B THDS PER MIL-S-8879 THRU CSK 90°-120° TO .260-.280 DIA NEAR SIDE (2 PLACES)
.014 DIA
.279-.291 DIA HOLE C'BORE .50 DIA FILLET RADIUS .000-.005 (2 PLACES)
.014 DIA
1.00
.25
.370 BSC
4.37
3.250 BSC
2.250 BSC
3.990 BSC
2.490 BSC
3.00
1.625 BSC
1.530 BSC
.379 BSC
.905 BSC
.500 BSC
30° BSC
.005
.2500-28UNF-3B OR .2500-28UNJF-3B THDS PER MIL-S-8879 .44 MIN DEPTH COMPLETE THDS DRILL .94 MIN DEEP CSK 90°-120° TO .260-.280 DIA NEAR SIDE (2 PLACES)
.014 DIA
-3 SUPPORT
2.500 BSC
1.250 BSC
.1900-32UNF-3B OR .1900-32UNJF-3B THDS PER MIL-S-8879 .38 MIN DEPTH COMPLETE THDS DRILL .75 MIN DEEP CSK 90°-120° TO .200-.230 DIA NEAR SIDE (2 PLACES)
.014 DIA
.380
.75
3.55
2.000
.850R
.010
.375 BSC
1.875 BSC
2.30
1.470
.50
1.540 BSC
.770 BSC
.1120-40UNC-3B OR .1120-40UNJC-3B THDS PER MIL-S-8879 .20 MIN DEPTH COMPLETE THDS DRILL .36 MIN DEEP CSK 90°-120° TO .120-.140 DIA NEAR SIDE (2 PLACES)
.012 DIA
.150 BSC
-5 RETAINER
1.90
.95
.06R
1.00
.13
.850R
.010
3.10
1.55
.75
.380
1.250 BSC
2.500 BSC
.218-.229 DIA HOLE (2 PLACES)
.014 DIA
RP-007 SH 2
SCALE: 1/2
WHEEL ASSY-
DWN: TK MATSUMOTO 10-15-81
REV A (10-19-81)







-1 WHEEL ASSY

7 INSTALL LENS (9D) & RP-002-2 (2) RETAINER TO RP-002-1 WHEEL. TRIM ENDS OF RETAINER AS REQUIRED TO INSURE A BUTT JOINT WHEN INSTALLED.

8 BOND -8 TO -9

NOTES:

1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±.5°
2. 63/ALL MACHINED SURFACES.
3. MATERIAL: 6061-T6 ALUMINUM
4. FINISH PER RAC 5884, TYPE II, CLASS 2, COLOR BLACK.
5. BREAK ALL SHARP EDGES.
6. MAKE FROM #13E20 NEWPORT RESEARCH CORP. FOUNTAIN VALLEY, CA.

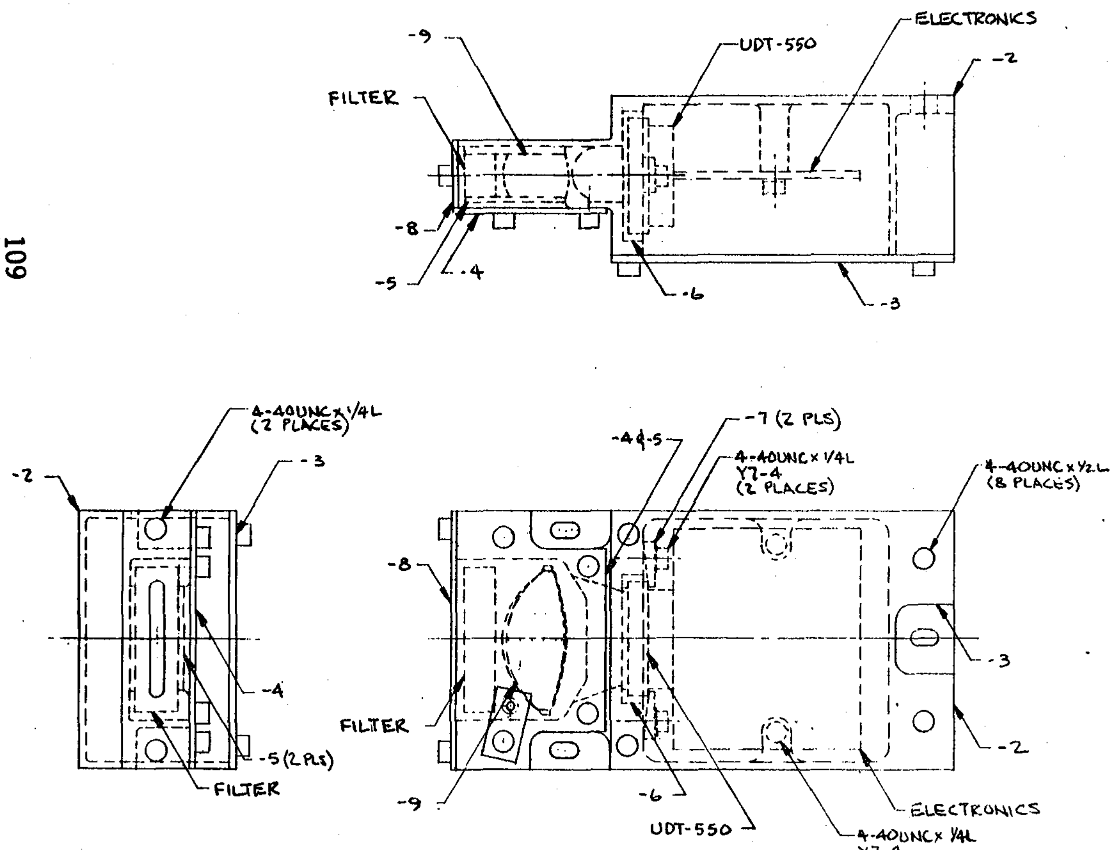
2	1/4-28UNF x 1/2L	CAP SCREW	MATL 304 CRES
4	10-32UNF x 5/16L	CAP SCREW	MATL 304 CRES
2	4-40UNC x 1/2L	CAP SCREW	MATL 304 CRES
2	4-40UNC x 5/32L	SET SCREW	MATL 304 CRES
1	75A120-2	MOTOR	TRW GLOBE MOTOR
2	RP-002-2	RETAINER	
1	RP-002-1	WHEEL	
1	-10	RETAINER	3 4
1	-9	ROD	3 4
1	-8	MIRROR	
1	-7	PRISM	6
2	-6	RETAINER	3 4
1	-5	RETAINER	3 4
1	-4	SUPPORT	3 4
1	-3	SUPPORT	3 4
1	-2	SUPPORT	3 4
–	-1	WHEEL ASSY	
-1	PART NO.	NOMENCLATURE	REMARKS

RP-007 SH 1 OF 2
SCALE: 1/2
WHEEL ASSY-
DWN: TK MATSUMOTO 9-18-81

REV A (10-15-81)

NOTES:

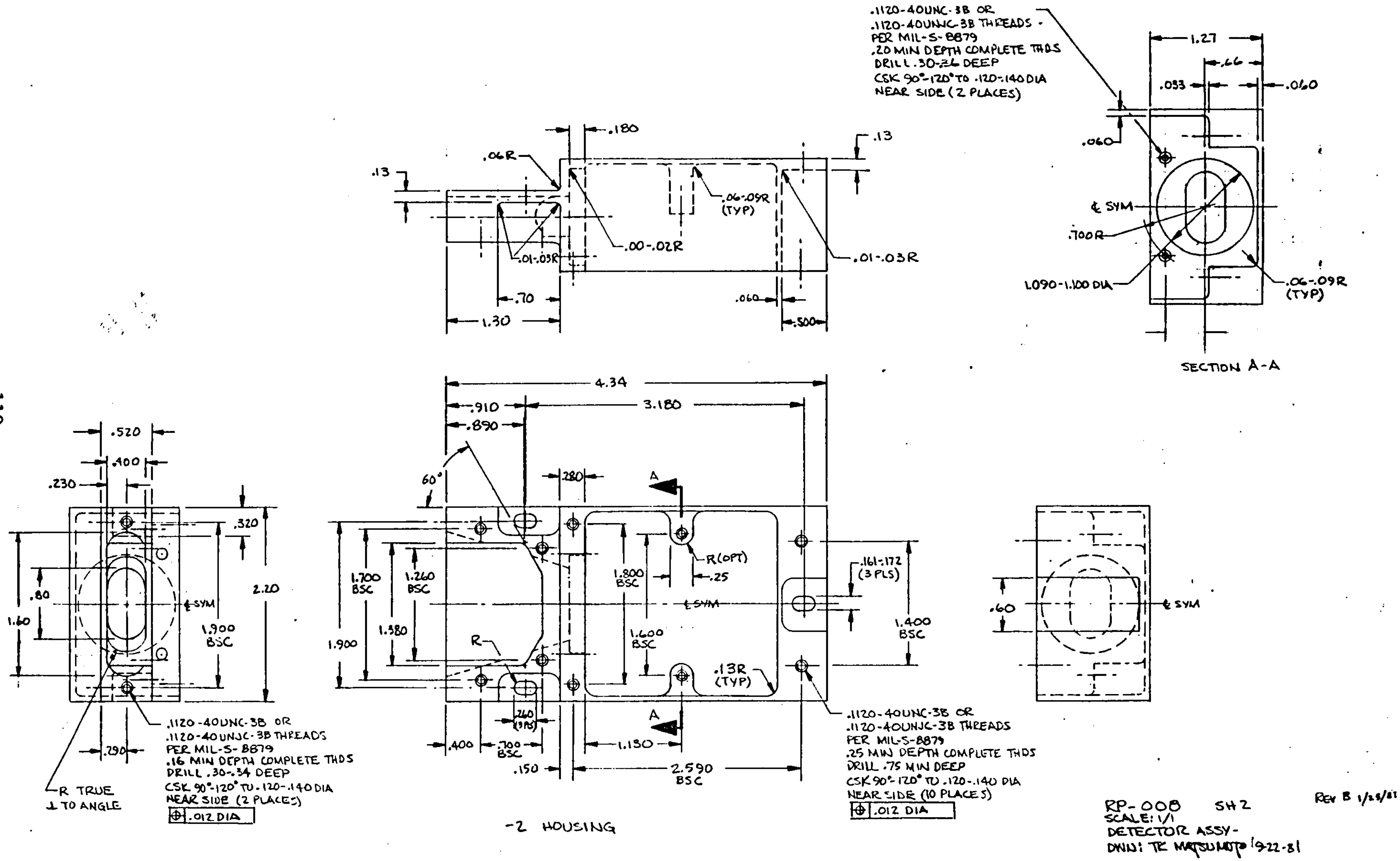
1. TOLERANCE:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ ALL MACHINED SURFACES
3. MATERIAL: CDA #544 FREE CUTTING PHOSPHOR BRONZE
5. BREAK ALL SHARP EDGES.
6. MATERIAL: RUBBER 1/16 x .83 x .90
7. MAKE FROM MELLES GRIOT #01 LAG 115
8. MATERIAL: NYLON OR PHENOLIC BLOCK

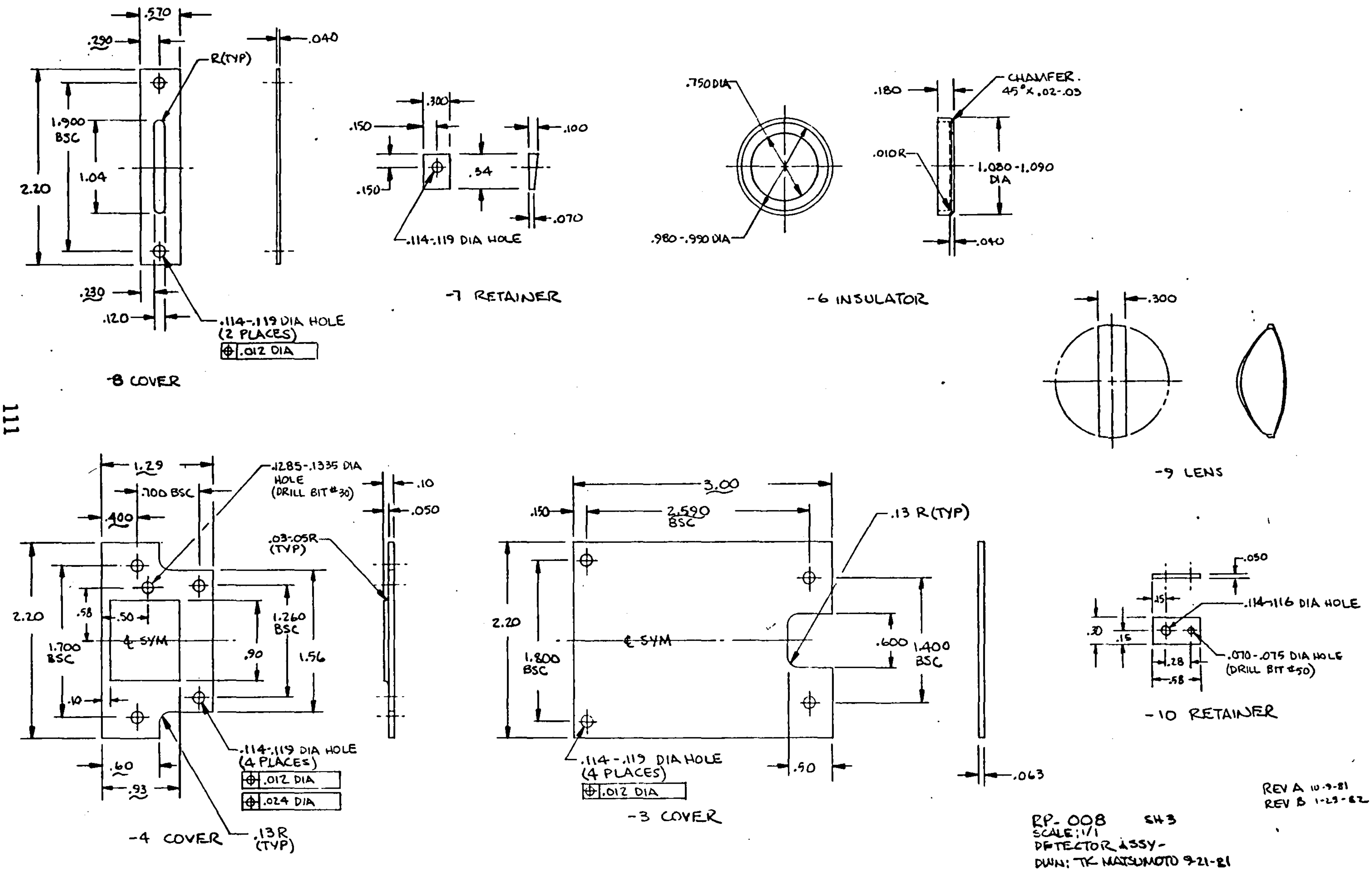


	-1	PART NO.	NOMENCLATURE	REMARKS
	4	Y7-4	WASHER	MATL 304 CRES
	2	4-40UNC x 1/8L	CAP SCREW	MATL 304 CRES
	12	4-40UNC x 1/4L	CAP SCREW	MATL 304 CRES
	1	UDT-550	DETECTOR	
	1		ELECTRONICS	
	1		FILTER	
	1	-10	RETAINER	NYLON COLOR BLACK
	1	-9	LENS	7
	1	-8	COVER	3
	2	-7	RETAINER	8
	1	-6	INSULATOR	8
	1	-5	GASKET	6
	1	-4	COVER	3
	1	-3	COVER	3
	1	-2	HOUSING	3
	—	-1	DETECTOR ASSY	

REV A 10-9-81
REV B 1/25/82

RP-008 SH 1 OF 3
SCALE: 1/1
DETECTOR ASSY -
DWN: TK MATSUMOTO 9-21-81

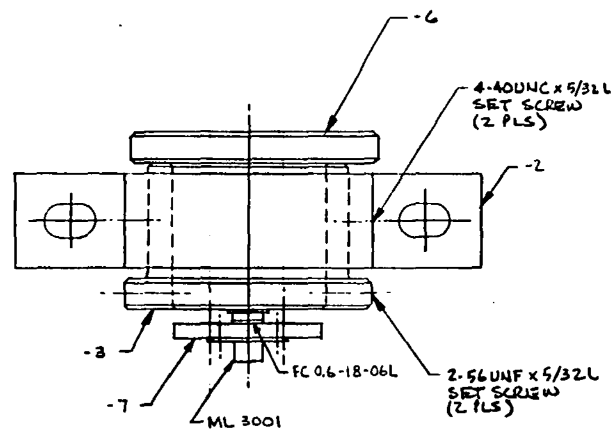

.1120-40UNC-3B OR
.1120-40UNJC-3B THREADS -
PER MIL-S-8879
.20 MIN DEPTH COMPLETE THDS
DRILL .30-.26 DEEP
CSK 90°-120° TO .120-.140 DIA
NEAR SIDE (2 PLACES)
.180
.13
.06R
.13
.06-.09R (TYP)
.00-.02R
.01-.03R
.01-.03R
.70
1.30
.060
.500
1.27
.66
.033
.060
.060
℄ SYM
.700R
1.090-1.100 DIA
.06-.09R (TYP)
SECTION A-A
4.34
.910
3.180
.890
.520
.400
.230
.320
60°
.280
A
.80
1.60
2.20
1.900 BSC
℄ SYM
1.700 BSC
1.260 BSC
1.380
1.900
R
1.800 BSC
R(OPT)
.25
1.600 BSC
℄ SYM
.161-.172 (3 PLS)
1.400 BSC
.60
℄ SYM
.13R (TYP)
.240 (3 PLS)
A
.290
.400
.700 BSC
1.130
.150
2.590 BSC
R TRUE
⊥ TO ANGLE
.1120-40UNC-3B OR
.1120-40UNJC-3B THREADS
PER MIL-S-8879
.16 MIN DEPTH COMPLETE THDS
DRILL .30-.34 DEEP
CSK 90°-120° TO .120-.140 DIA
NEAR SIDE (2 PLACES)
⊕ .012 DIA
-2 HOUSING
.1120-40UNC-3B OR
.1120-40UNJC-3B THREADS
PER MIL-S-8879
.25 MIN DEPTH COMPLETE THDS
DRILL .75 MIN DEEP
CSK 90°-120° TO .120-.140 DIA
NEAR SIDE (10 PLACES)
⊕ .012 DIA
RP-008 SH 2
SCALE: 1/1
DETECTOR ASSY-
DWN: TK MATSUMOTO 9-22-81
Rev B 1/23/81

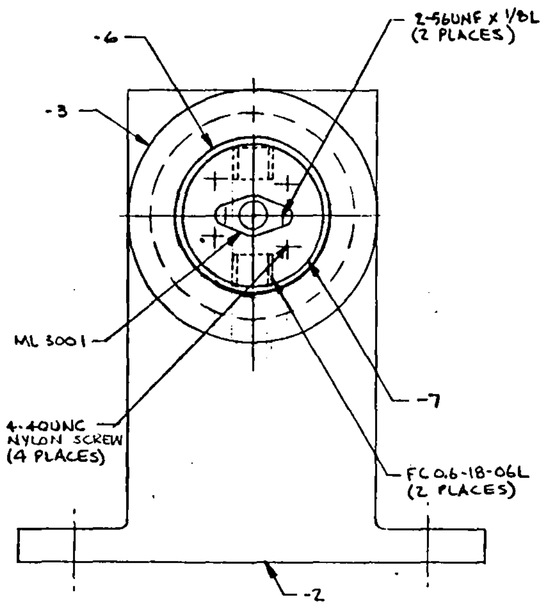


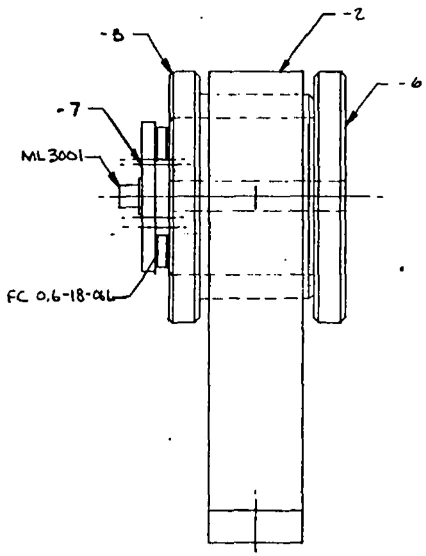
-8 COVER
.570
.290
R(TYP)
.040
1.900 BSC
1.04
2.20
.230
.120
.114-.119 DIA HOLE (2 PLACES)
.012 DIA
-7 RETAINER
.300
.150
.100
.34
.070
.114-.119 DIA HOLE
-6 INSULATOR
.750 DIA
.980-.990 DIA
.180
CHAMFER. 45°X.02-.03
.010R
1.080-1.090 DIA
.040
-9 LENS
.300
-4 COVER
1.29
.700 BSC
.400
.1285-.1335 DIA HOLE (DRILL BIT #30)
.10
.050
.03-.05R (TYP)
2.20
.58
.50
℄ SYM
1.700 BSC
.10
1.260 BSC
.90
1.56
.60
.93
.114-.119 DIA HOLE (4 PLACES)
.012 DIA
.024 DIA
.13R (TYP)
-3 COVER
3.00
.150
2.590 BSC
.13 R(TYP)
2.20
1.800 BSC
℄ SYM
.600
1.400 BSC
.114-.119 DIA HOLE (4 PLACES)
.012 DIA
.50
.063
-10 RETAINER
.050
.15
.114-.116 DIA HOLE
.30
.15
.070-.075 DIA HOLE (DRILL BIT #50)
.28
.58
REV A 10-9-81
REV B 1-29-82
RP-008 SH 3
SCALE: 1/1
DETECTOR ASSY-
DWN: TK MATSUMOTO 9-21-81

NOTES:

1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. $\overset{63}{\surd}$ ALL MACHINED SURFACES.
3. [3] MATERIAL: ALUMINUM 6061-T6
4. [4] FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK
5. BREAK ALL SHARP EDGES.
6. [6] MATERIAL: NYLON OR PHENOLIC BLOCK





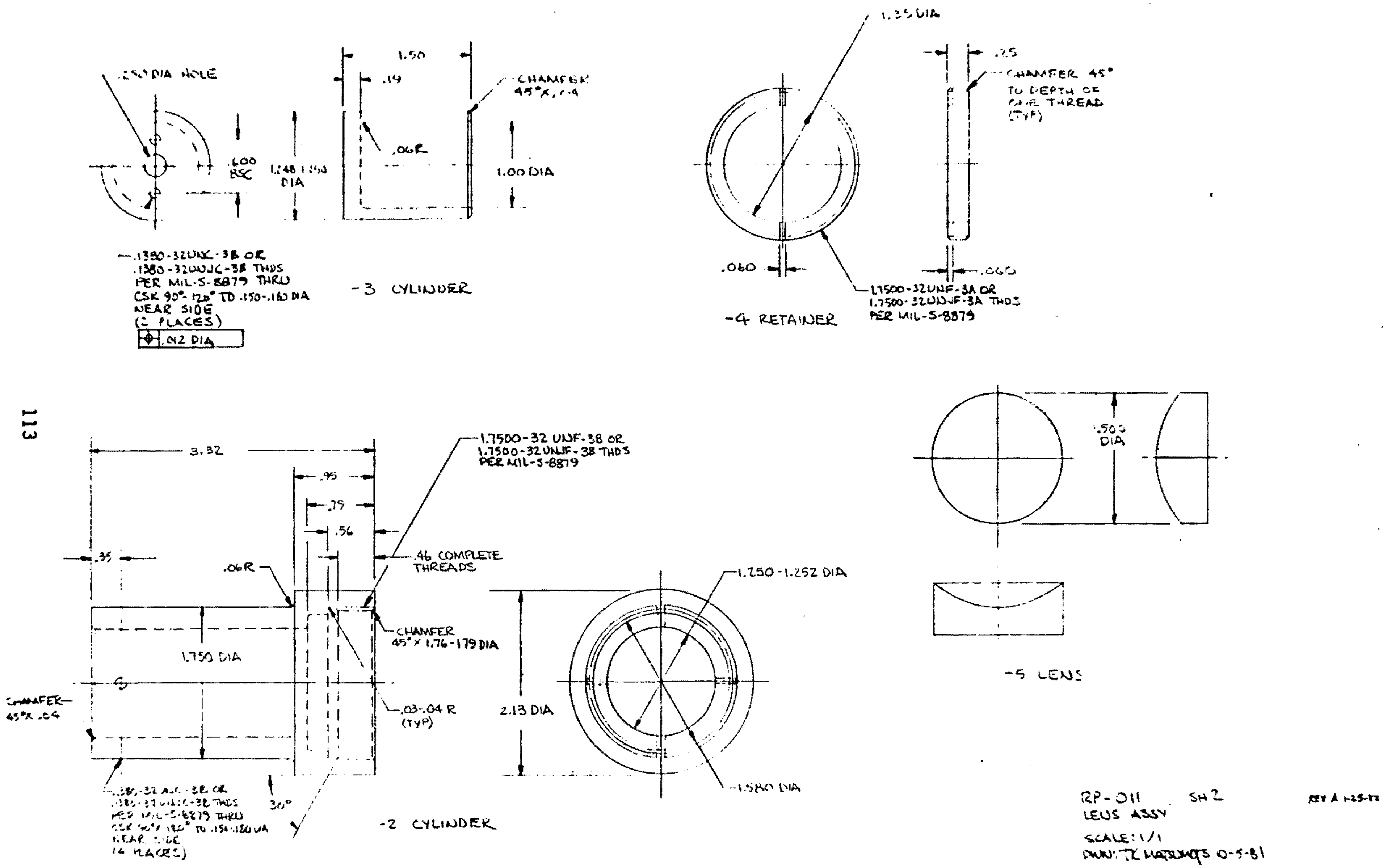


-1 LASER DIODE ASSY

	2	FC 0.6-18-06L	INSULATOR	
	4	4-40UNC	NYLON SCREW	
	2	2-56UNF x 1/8L	CAP SCREW	MATL 304 CRES
	2	4-40UNC x 5/32L	SET SCREW	MATL 304 CRES
	2	2-56UNF x 5/32L	SET SCREW	MATL 304 CRES
	1	-7	COLD PLATE	[3] [4]
	1	-6	CYLINDER	[3] [4]
	1	-3	CYLINDER	[3] [4]
	1	-2	MOUNT	[3] [4]
	—	-1	LASER DIODE ASSY	
	-1	PART NO.	NOMENCLATURE	REMARKS

RP-009 SH 1 OF 2
LASER DIODE MOUNT
SCALE: 1/1
DWN: TK MATSUMOTO 10-1-81

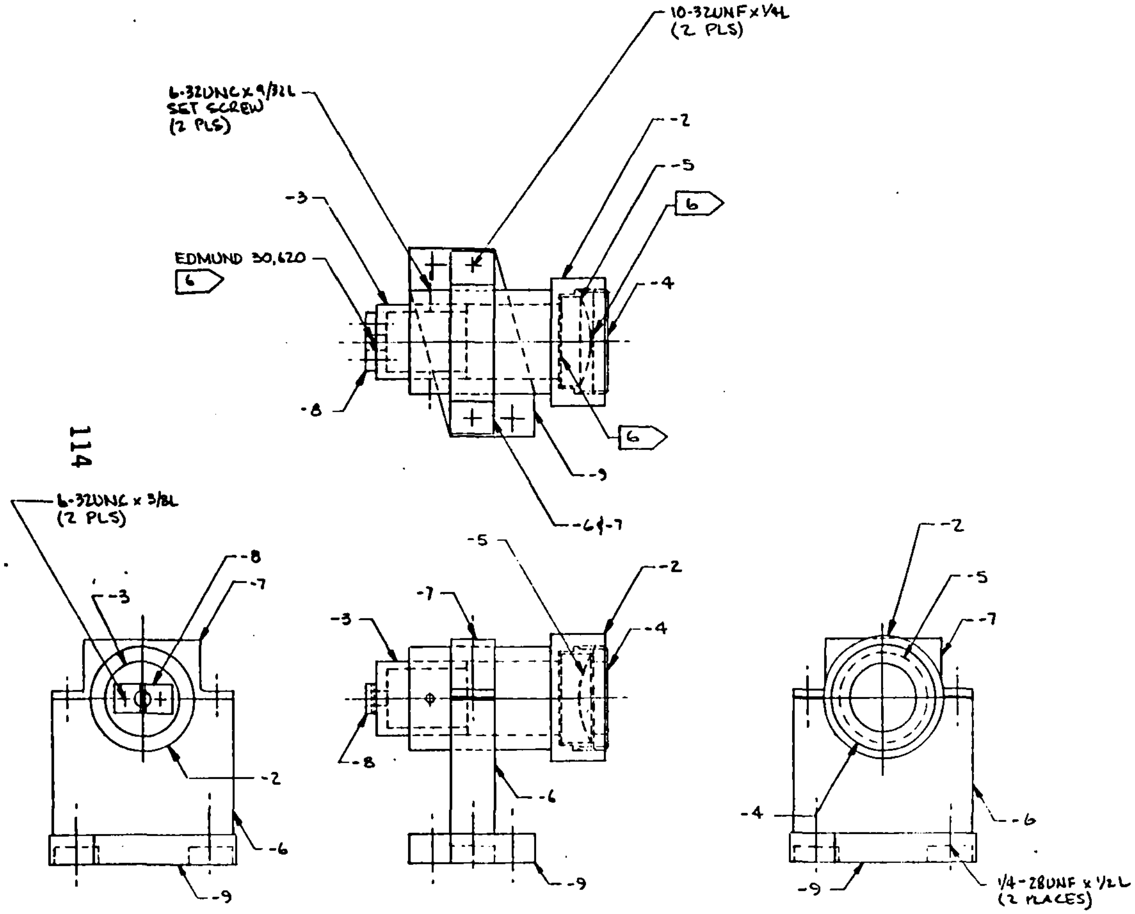
REV A 12-1-81
REV B 2-5-82



.250 DIA HOLE
.600 BSC
1.248-1.250 DIA
1.50
.19
CHAMFER 45° X .04
.06R
1.00 DIA
.1380-32UNC-3B OR
.1380-32UNJC-3B THDS
PER MIL-S-8879 THRU
CSK 90°-120° TO .150-.160 DIA
NEAR SIDE
(2 PLACES)
.012 DIA
-3 CYLINDER
1.35 DIA
.25
CHAMFER 45° TO DEPTH OF ONE THREAD (TYP)
.060
.060
1.7500-32UNF-3A OR
1.7500-32UNJF-3A THDS
PER MIL-S-8879
-4 RETAINER
1.500 DIA
-5 LENS
3.32
.95
.79
.56
.35
.06R
.46 COMPLETE THREADS
1.7500-32 UNF-3B OR
1.7500-32 UNJF-3B THDS
PER MIL-S-8879
CHAMFER 45° X 1.76-1.79 DIA
1.750 DIA
CHAMFER 45° X .04
.03-.04 R (TYP)
30°
-2 CYLINDER
2.13 DIA
1.250-1.252 DIA
1.580 DIA
RP-011 SH 2
LENS ASSY
SCALE: 1/1
REV A

NOTES:

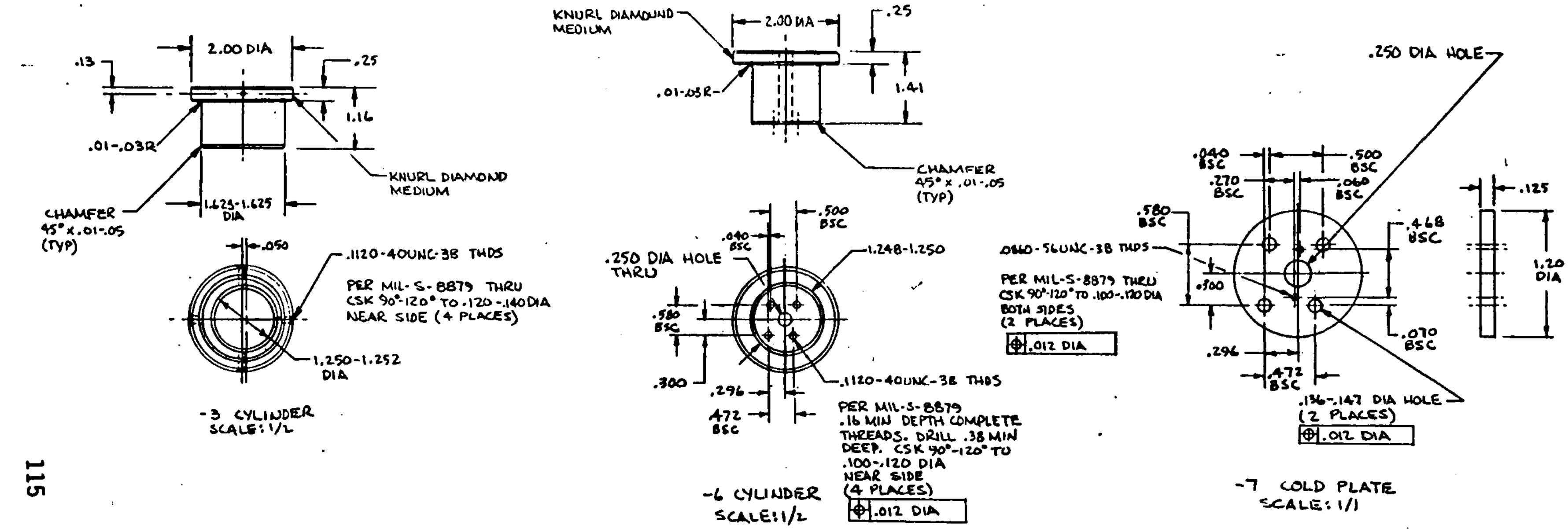
1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ ALL MACHINED SURFACES.
3. MATERIAL: ALUMINUM 6061-T6.
4. FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK.
5. BREAK ALL SHARP EDGES.
6. INSTALL GASKET USING PTFE .040 THICK.

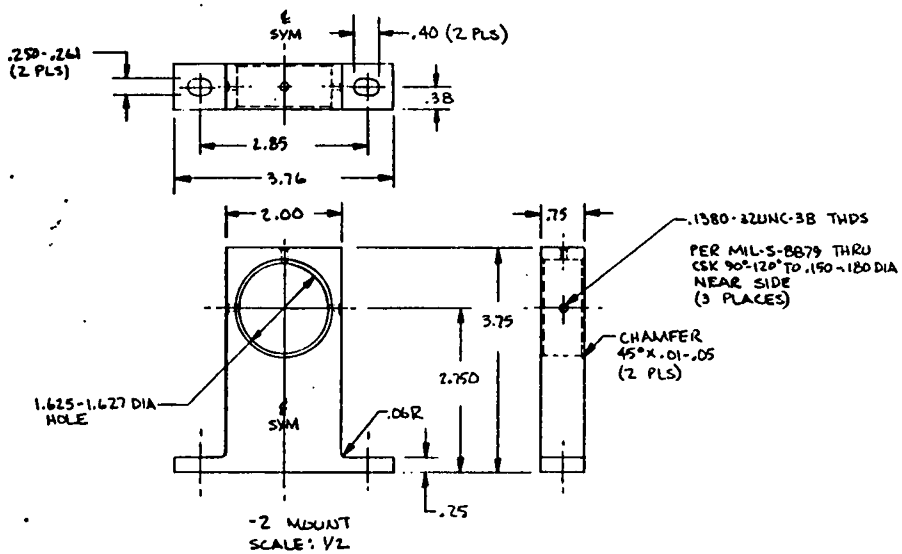


-1 LENS ASSY

	2	1/4-28UNF x 1/2L	SCREW	MATL 304 CRES
	2	10-32UNF x 1/4L	SCREW	MATL 304 CRES
	2	6-32UNC x 3/8L	SCREW	MATL 304 CRES
	2	6-32UNC x 9/32L	SET SCREW	MATL 304 CRES
	1	EDMUND 30,620	LENS	
	1	-9	BASE	3 4
	1	-8	PLATE	3 4
	1	-7	RETAINER	3 4
	1	-6	SUPPORT	3 4
	1	-5	LENS	MAKE FROM EDMUND 30,240
	1	-4	RETAINER	3 4
	1	-3	CYLINDER	3 4
	1	-2	CYLINDER	3 4
	-	-1	LENS ASSY	
	-1	PART NO.	NOMENCLATURE	REMARKS

RP-011 SH 1 OF 3 REV A 1-29-82
LENS ASSY
SCALE: 1/2
DWN: TK MATSUMOTO 10-5-81



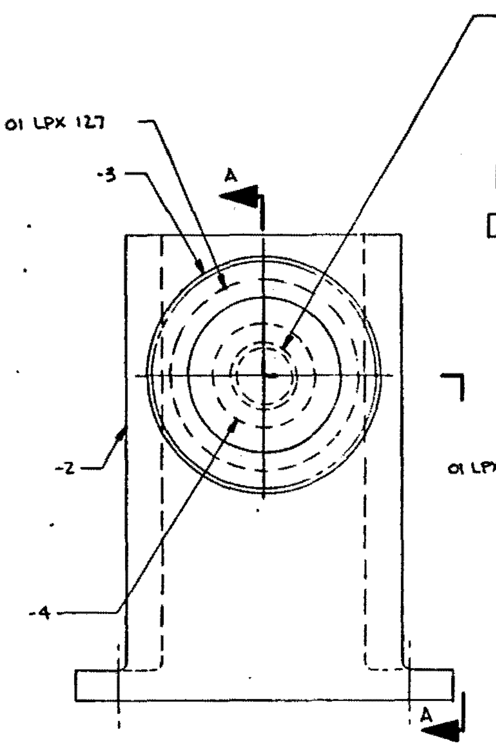


RP-009 SH2
LASER DIODE MOUNT
SCALE: NOTED
DWN: TK MATSUMOTO 10-1-81

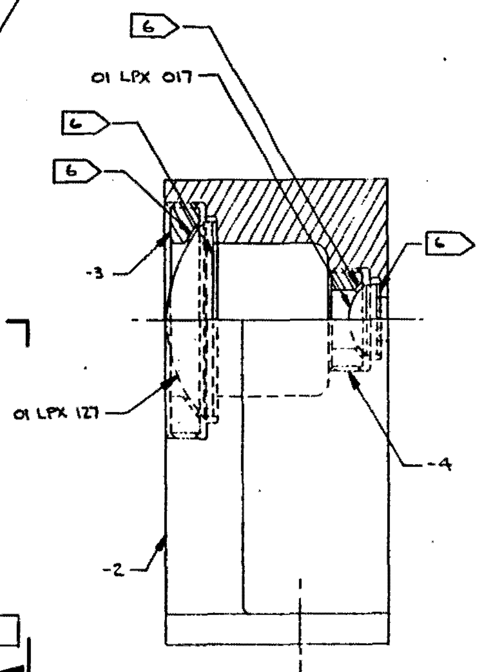
REV A 12-1-81
REV B 2-5-82

NOTES:

1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63√ ALL MACHINED SURFACES.
3. MATERIAL: ALUMINUM 6061-T6.
4. FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK.
5. BREAK ALL SHARP EDGES.
6. INSTALL GASKET USING PTFE .040 THICK.



-1 LENS ASSY - DIODE LASER

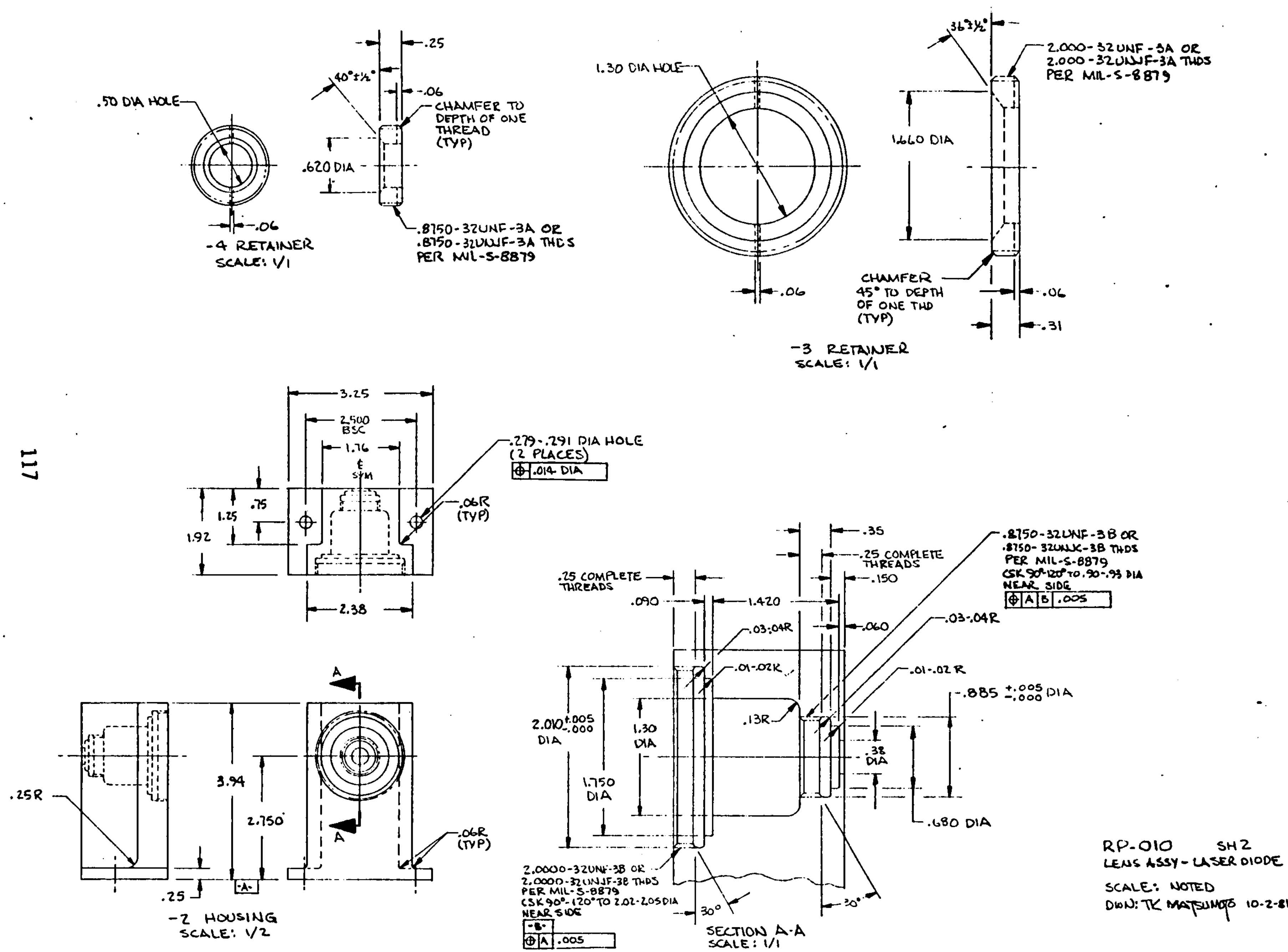


SECTION A-A

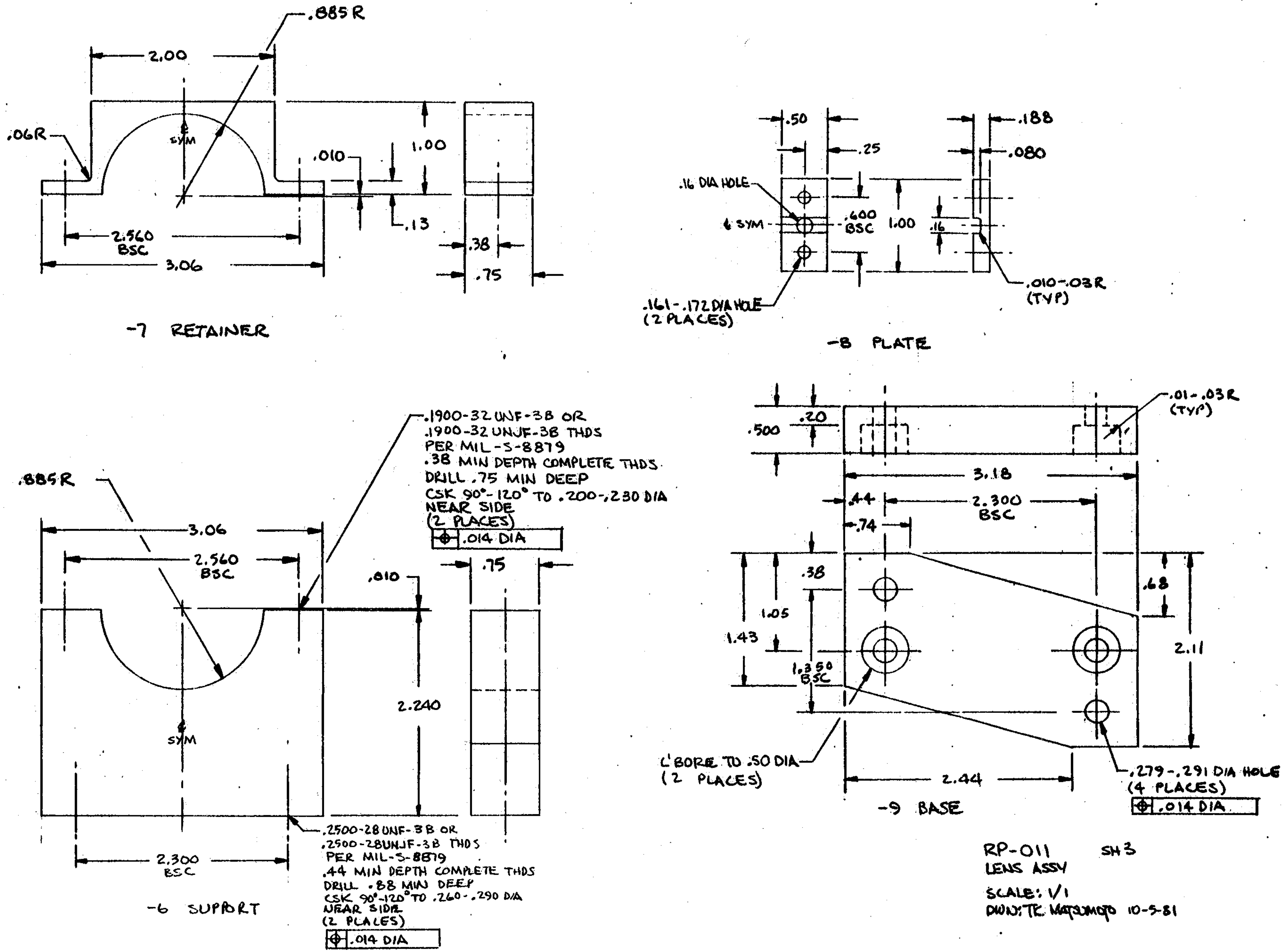
	1	01 LPX 127	LENS	MELLES GRIOT OPTIC GUIDE CAT
	1	01 LPX 017	LENS	MELLES GRIOT OPTIC GUIDE CAT
	1	-4	RETAINER	3 4
	1	-3	RETAINER	3 4
	1	-2	MOUNT	3 4
	–	-1	LENS ASSY-	
	-1	PART NO.	NOMENCLATURE	REMARKS

RP-OKO SH 1 OF 2
LENS ASSY - LASER DIODE

SCALE: 1/1
DWN: R MATSUMOTO 10-5-81



.50 DIA HOLE
40°±½°
.25
.06
CHAMFER TO DEPTH OF ONE THREAD (TYP)
.620 DIA
.06
-4 RETAINER
SCALE: 1/1
.8750-32UNF-3A OR .8750-32UNJF-3A THDS PER MIL-S-8879
1.30 DIA HOLE
36°±½°
2.000-32UNF-3A OR 2.000-32UNJF-3A THDS PER MIL-S-8879
1.660 DIA
.06
CHAMFER 45° TO DEPTH OF ONE THD (TYP)
.06
.31
-3 RETAINER
SCALE: 1/1
3.25
2.500 BSC
1.76
℄ SYM
.279-.291 DIA HOLE (2 PLACES)
.014 DIA
.06R (TYP)
1.92
1.25
.75
2.38
A
A
.25R
3.94
2.750
.25
-A-
.06R (TYP)
-2 HOUSING
SCALE: 1/2
.35
.25 COMPLETE THREADS
.150
.25 COMPLETE THREADS
.090
1.420
.060
.8750-32UNF-3B OR .8750-32UNJF-3B THDS PER MIL-S-8879 CSK 90°-120° TO .90-.93 DIA NEAR SIDE
A B .005
.03-.04R
.03-.04R
.01-.02R
.01-.02 R
.885 +.005 -.000 DIA
2.010 +.005 -.000 DIA
1.30 DIA
.13R
.38 DIA
1.750 DIA
.680 DIA
2.0000-32UNF-3B OR 2.0000-32UNJF-3B THDS PER MIL-S-8879 CSK 90°-120° TO 2.02-2.05 DIA NEAR SIDE
-B-
A .005
30°
30°
SECTION A-A
SCALE: 1/1
RP-010 SH 2
LENS ASSY - LASER DIODE
SCALE: NOTED
DWN: TK MATSUMOTO 10-2-81



.885 R
2.00
.06R
℄ SYM
1.00
.010
.13
2.560 BSC
3.06
.38
.75
-7 RETAINER
.50
.25
.188
.080
.16 DIA HOLE
℄ SYM
.600 BSC
1.00
.16
.010-.03R (TYP)
.161-.172 DIA HOLE (2 PLACES)
-8 PLATE
.1900-32 UNF-3B OR
.1900-32 UNJF-3B THDS
PER MIL-S-8879
.38 MIN DEPTH COMPLETE THDS
DRILL .75 MIN DEEP
CSK 90°-120° TO .200-.230 DIA
NEAR SIDE
(2 PLACES)
.014 DIA
.885R
3.06
2.560 BSC
.010
.75
℄ SYM
2.240
2.300 BSC
-6 SUPPORT
.2500-28 UNF-3B OR
.2500-28UNJF-3B THDS
PER MIL-S-8879
.44 MIN DEPTH COMPLETE THDS
DRILL .88 MIN DEEP
CSK 90°-120° TO .260-.290 DIA
NEAR SIDE
(2 PLACES)
.014 DIA
.20
.500
.01-.03R (TYP)
3.18
.44
2.300 BSC
.74
.38
1.05
1.43
1.350 BSC
.68
2.11
C'BORE TO .50 DIA (2 PLACES)
2.44
.279-.291 DIA HOLE (4 PLACES)
.014 DIA
-9 BASE
RP-011 SH 3
LENS ASSY
SCALE: 1/1
DWN: T.K. MATSUMOTO 10-5-81

11. MIN GAP OF .002 WHEN -5, -6 & -9 OR -10 ARE ASSEMBLED
12. MIN GAP OF .002 WHEN -17, RP-007-10 & -10 OR RP-007-1 ARE ASSEMBLED.
13. MIN GAP OF .002 WHEN -12, RP-011-7 & H-3025P ARE ASSEMBLED.

	1	H-3025P	LASER	
	2	¼-28UNF x ¾L	CAP SCREW	304 STAINLESS
	18	¼-28UNF x ⅜L	CAP SCREW	304 STAINLESS
	4	10-32UNF x 1.0L	CAP SCREW	304 STAINLESS
	15	10-32UNF x ⅜L	CAP SCREW	304 STAINLESS
	3	6-32UNC x 1.0L	CAP SCREW	304 STAINLESS
	2	6-32UNC x ½L	CAP SCREW	304 STAINLESS
	10	6-32UNC x 3/8L	CAP SCREW	304 STAINLESS
	10	4-40UNC x 5/16L	CAP SCREW	304 STAINLESS
	4	4-40UNC x ¼L	CAP SCREW	304 STAINLESS
	4	8-32UNC x ⅜L	CAP SCREW	304 STAINLESS
	2	RP-011-7	SUPPORT	
	1	RP-011-1	LENS ASSY.	
	1	RP-010-1	LENS ASSY.	
	1	RP-009-1	LASER DIODE MOUNT	
	5	RP-008-1	DETECTOR ASSY	
		RP-007-10	RETAINER	
	1	RP-007-1	WHEEL ASSY	
	-1	PART NO	NOMENCLATURE	REMARKS

NOTES:

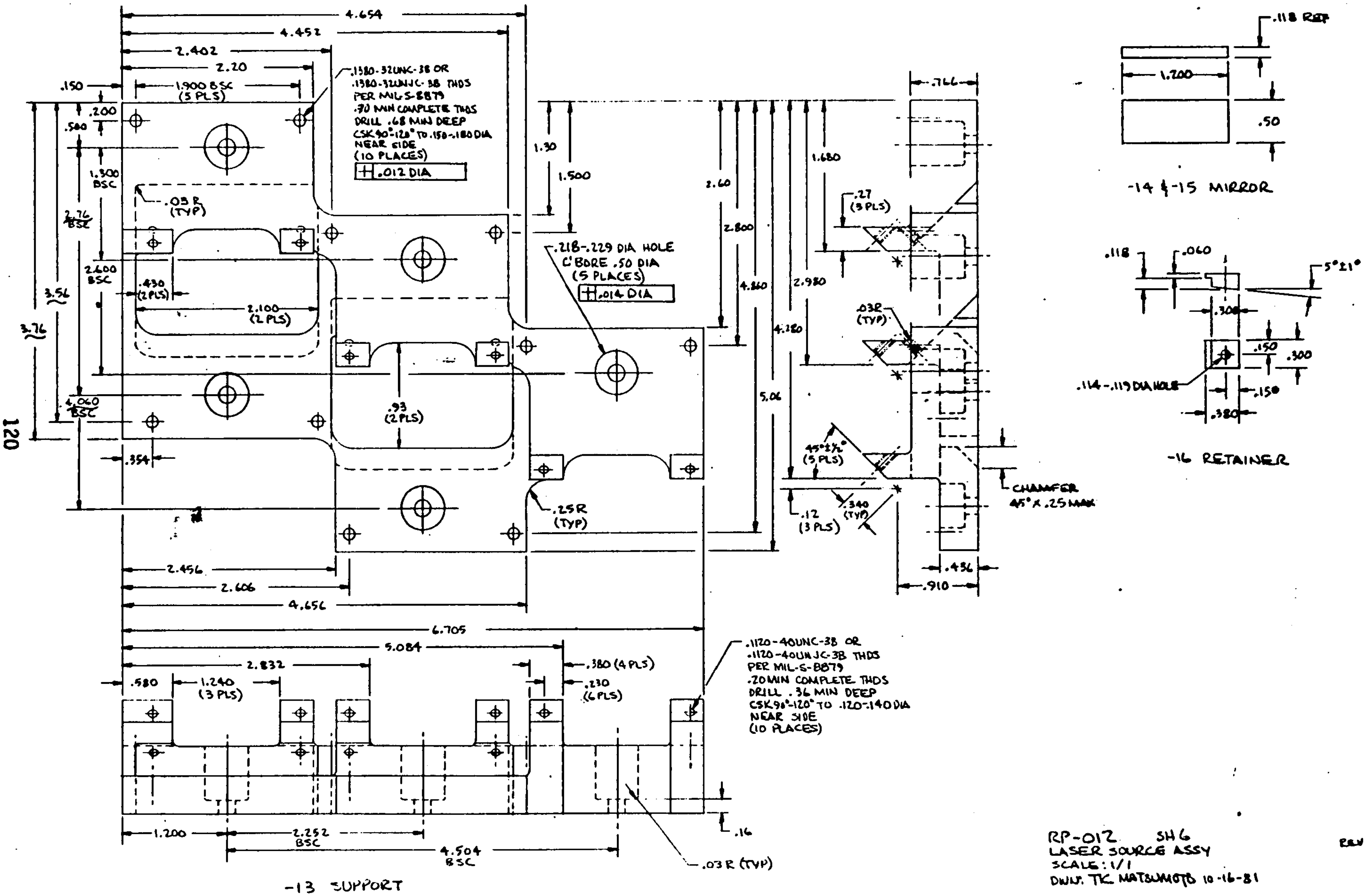
1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ALL MACHINED SURFACES.
3. MATERIAL: 6061-T6 ALUMINUM.
4. FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK.
5. BREAK ALL SHARP EDGES.
6. MAKE FROM
7. BOND MIRROR TO ROD
8. INSTALL .75 DIA SHIM TO MAINTAIN ALIGNMENT OF DETECTOR. NOMINAL HEIGHT OF SHIM .196
9. INSTALL .75 DIA SHIM TO MAINTAIN ALIGNMENT OF DETECTOR. NOMINAL HEIGHT OF SHIM .526
10. ALL FILLET RADIUS .06 EXCEPT AS NOTED.

	1	-17	SUPPORT	3 4
	10	-16	RETAINER	3 4
	3	-15	MIRROR	
	2	-14	MIRROR	
	1	-13	SUPPORT	3 4
	2	-12	SUPPORT	3 4
	1	-11	BASE PLATE	3 4
	1	-10	ROD	3 4
	2	-9	ROD	3 4
	1	-8	MIRROR	
	2	-7	MIRROR	
	2	-6	RETAINER	3 4
	2	-5	SUPPORT	3 4
	2	-4	RETAINER	3 4
	1	-3	BEAM COMBINER	
	1	-2	SUPPORT	3 4
	—	-1	LASER SOURCE ASSY	
	-1	PART NO	NOMENCLATURE	REMARKS

RP-012 SH 1 OF 7
LASER SOURCE ASSY

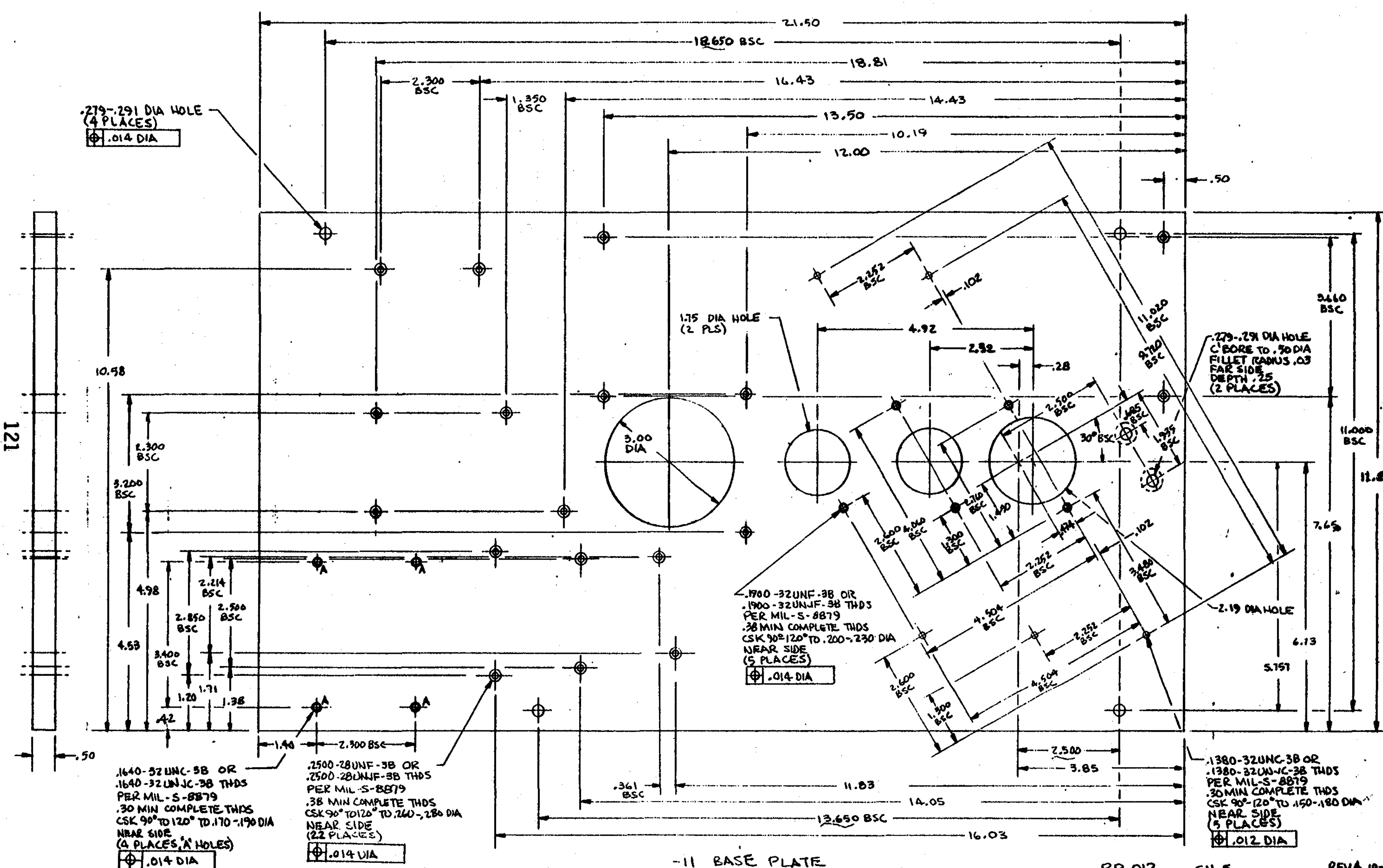
REV A 10-16-81
REV B 12/4/81
REV C 2/10/82

DWN: TK MATSUMOTO 10-8-81



RP-012 SH 6
LASER SOURCE ASSY
SCALE: 1/1
DWN: TK MATSUMOTO 10-16-81

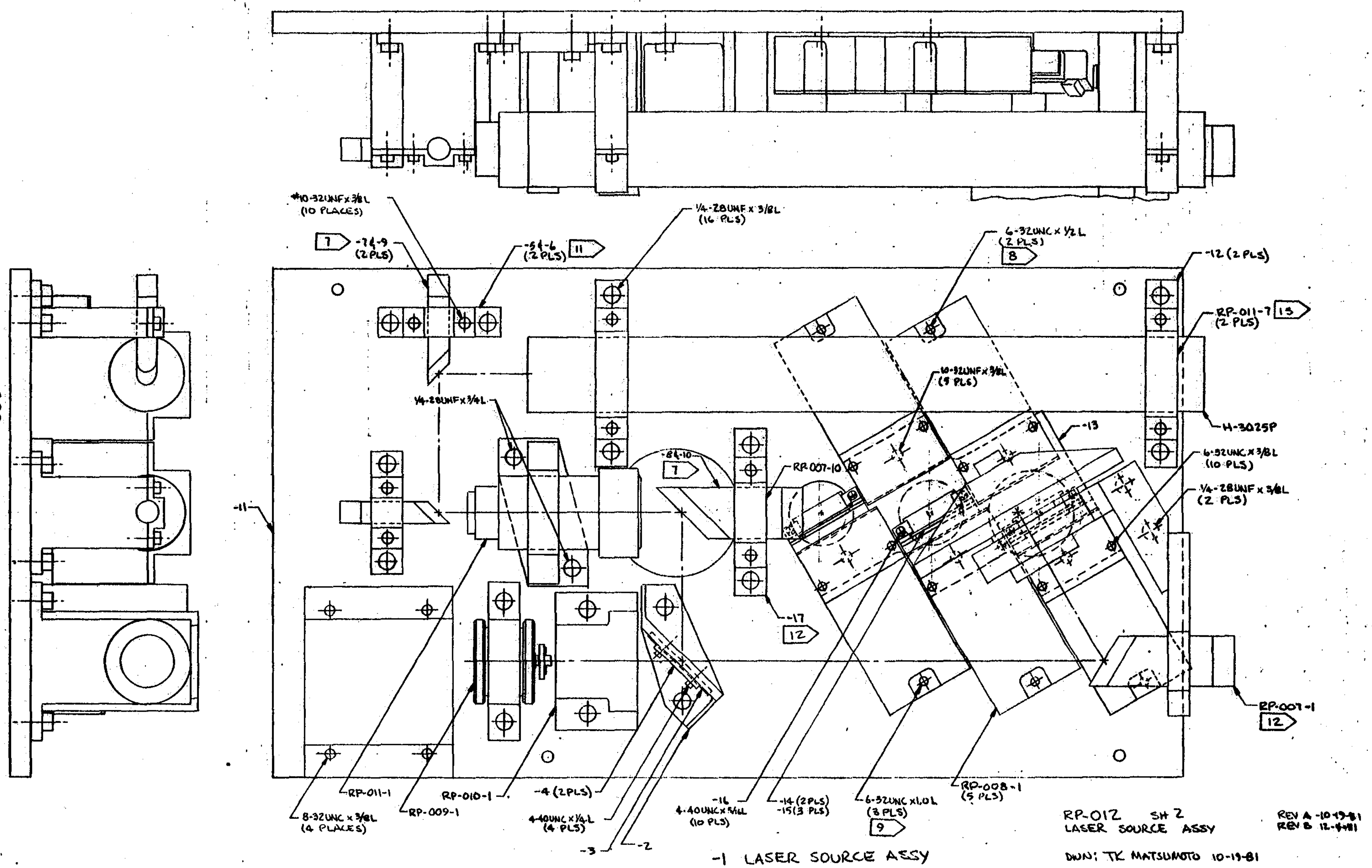
REV B



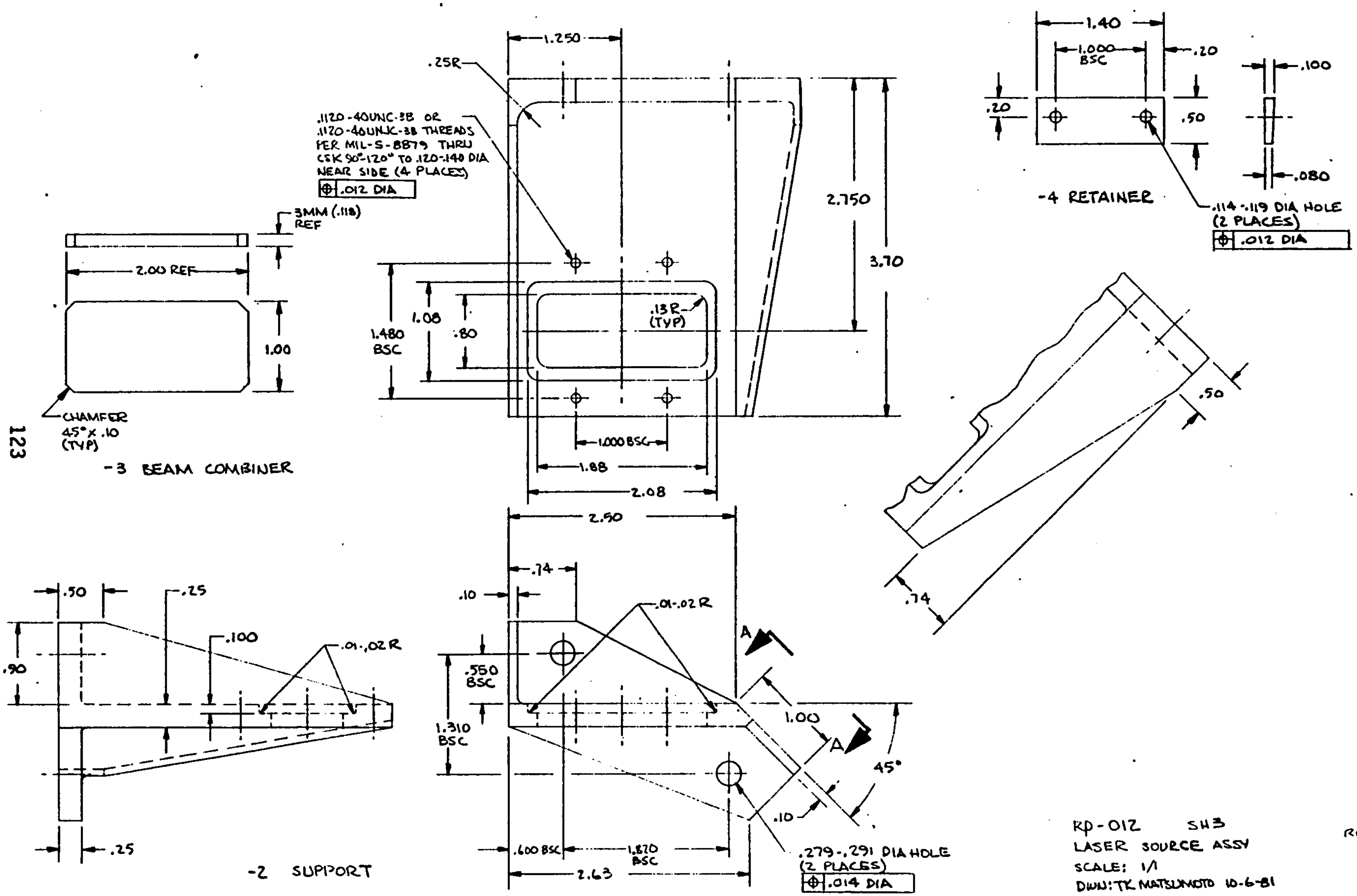
-11 BASE PLATE

RP-012 SH 5
LASER SOURCE ASSY
SCALE: 1/2
DWN: T.K. MATSUMOTO 10-19-81

REV A 10-19-81
REV B 12-4-81
REV C 2-17-82



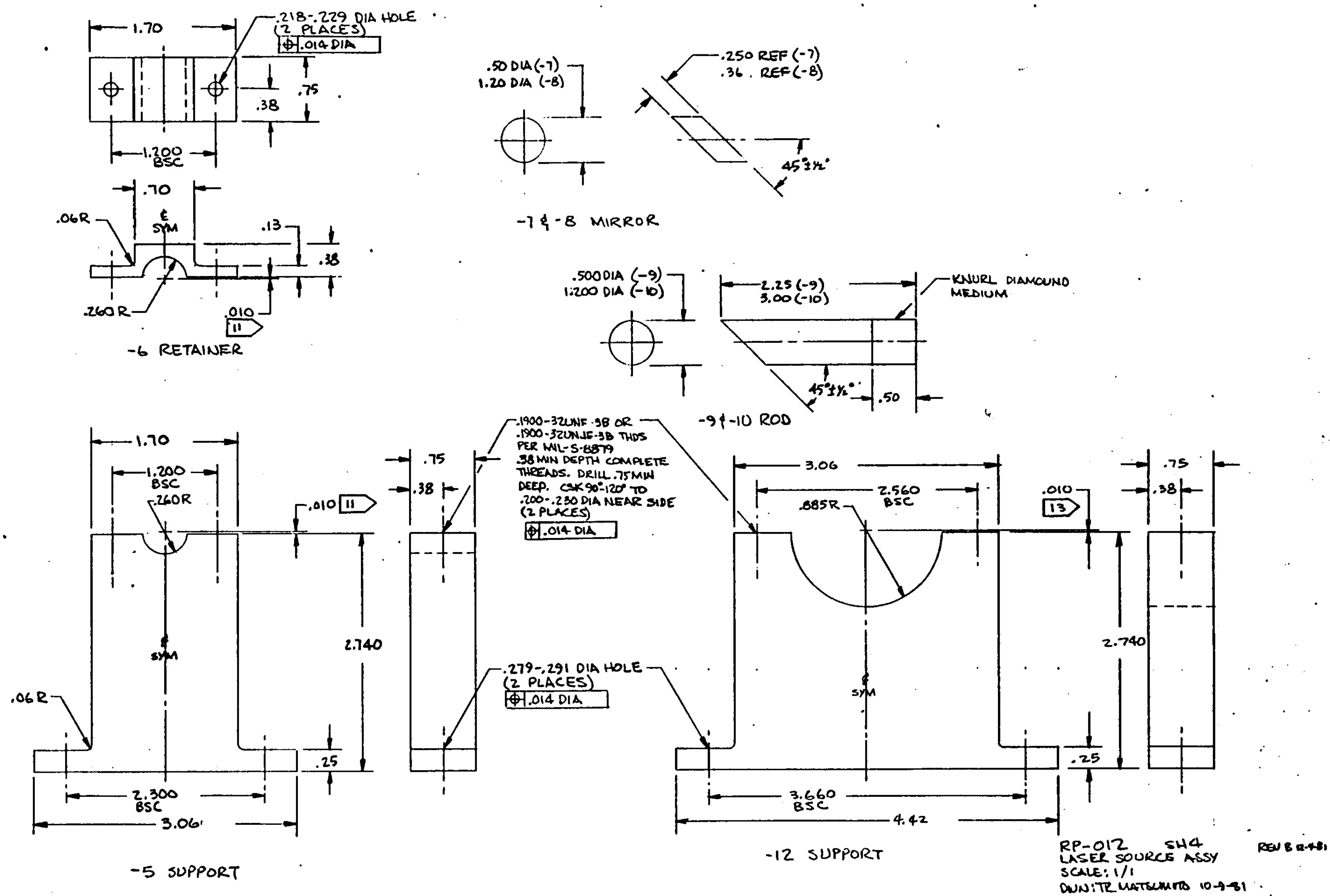
#10-32UNF x 3/8L (10 PLACES)
1/4-28UNF x 3/8L (16 PLS)
6-32UNC x 1/2L (2 PLS)
8
-12 (2 PLS)
7
-7 & -9 (2 PLS)
-5 & -6 (2 PLS)
11
RP-011-7 (2 PLS)
13
10-32UNF x 3/8L (5 PLS)
1/4-28UNF x 3/4L
H-3025P
-13
-8 & -10
7
RP-007-10
6-32UNC x 3/8L (10 PLS)
1/4-28UNF x 3/8L (2 PLS)
-11
-17
12
RP-007-1
12
RP-011-1
8-32UNC x 3/8L (4 PLACES)
RP-009-1
RP-010-1
-4 (2 PLS)
4-40UNC x 1/4L (4 PLS)
-3
-2
-16
4-40UNC x 5/16L (10 PLS)
-14 (2 PLS)
-15 (3 PLS)
6-32UNC x 1.0L (3 PLS)
9
RP-008-1 (5 PLS)
RP-012 SH 2
LASER SOURCE ASSY
REV A -10-19-81
REV B 12-4-81
-1 LASER SOURCE ASSY
DWN: TK MATSUMOTO 10-19-81



123

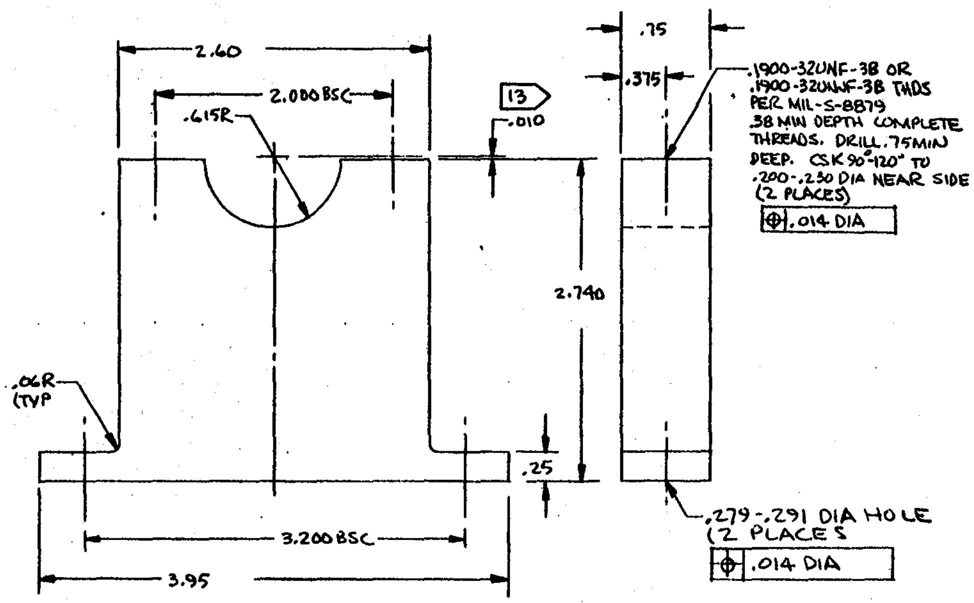
KP-012 SH3
LASER SOURCE ASSY
SCALE: 1/1
DWN: TK MATSUMOTO 10-6-81

REV B 11/4/81



.218-.229 DIA HOLE (2 PLACES)
.014 DIA
1.70
.75
.38
1.200 BSC
.70
.06R
℄ SYM
.13
.38
.260R
.010
11
-6 RETAINER
.50 DIA (-7)
1.20 DIA (-8)
.250 REF (-7)
.36 REF (-8)
45°±½°
-7 & -8 MIRROR
.500 DIA (-9)
1.200 DIA (-10)
2.25 (-9)
3.00 (-10)
KNURL DIAMOND MEDIUM
45°±½°
.50
-9 & -10 ROD
.1900-32UNF-3B OR .1900-32UNJF-3B THDS PER MIL-S-8879 .38 MIN DEPTH COMPLETE THREADS. DRILL .75 MIN DEEP. CSK 90°-120° TO .200-.230 DIA NEAR SIDE (2 PLACES)
.014 DIA
.279-.291 DIA HOLE (2 PLACES)
.014 DIA
1.70
1.200 BSC
.260R
.010
11
.75
.38
2.740
℄ SYM
.06R
.25
2.300 BSC
3.06
-5 SUPPORT
3.06
2.560 BSC
.885R
.010
13
.75
.38
2.740
℄ SYM
.25
3.660 BSC
4.42
-12 SUPPORT
RP-012 SH4
LASER SOURCE ASSY
SCALE: 1/1
DWN: TR MATSUMOTO 10-9-81
REV B 12-4-81

124



-17 SUPPORT

RP-012 SH7
LASER SOURCE ASSY
SCALE: 1/1
DWN: T.K. MATSUMOTO 10-19-81

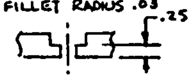
REV A [illegible]
REV B 12-[illegible]

[14] .1380-32UNC-3B OR
.1380-32UNJF-3B THDS
PER MIL-S-8879
.25 MIN COMPLETE THDS
CSK 90°-120° TO .150-.180 DIA

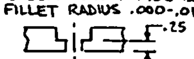
[15] .279-.291 DIA HOLE
CSK 100° x .515-.525 DIA
NEAR SIDE

[16] 32/ FINISH TO ALL O-RING
GROOVE SURFACES.

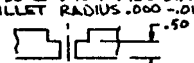
[17] .136-.147 DIA HOLE
C'BORE .313 DIA
FILLET RADIUS .03



[9] .279-.291 DIA HOLE
C'BORE .404-.406 DIA.
FILLET RADIUS .000-.012 R



[10] .279-.291 DIA HOLE
C'BORE .404-.406 DIA
FILLET RADIUS .000-.012 R



[11] PRESS FIT FOR .313 DIA DOWEL PIN
THRU, SEE RP-015.

[12] .2500-28UNF-3B OR
.2500-28UNJF-3B THDS
PER MIL-S-8879
.44 MIN COMPLETE THDS
DRILL .75 MAX DEEP
CSK 90°-120° TO .260-.280 DIA

[13] .1900-32UNF-3B OR
.1900-32UNJF-3B THDS
PER MIL-S-8879
.38 MIN COMPLETE THDS
CSK 90°-120° TO .200-.230 DIA
Torque = 3 ft-#

	40	BACB30LJ4-16	BOLT	
	40	MS21043-4	NUT	
	40	AN960C416	WASHER	
	2	1/4-28UNF x 1/2 LONG	100° CSK SCREW	MATL: 304 CRES
	4	1/4-28UNF x 1.00 LONG	CAP SCREW	MATL: 304 CRES
	6	1/4-28UNF x 7/8 LONG	CAP SCREW	MATL: 304 CRES
	45	1/4-28UNF x 1/2 LONG	CAP SCREW	MATL: 304 CRES
	4	10-32UNF x 1.00 LONG	CAP SCREW	MATL: 304 CRES
	4	BACF32D1	FERRULE	
	2	BACH10G3A	HANDLE	
	2	1/8 DIA	O-RING	
-2	-1	PART NO	NOMENCLATURE	REMARKS

NOTES:

1. TOLERANCES (EXCEPT AS NOTED)
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ALL MACHINED SURFACES (EXCEPT AS NOTED)

[3] MATERIAL: 6061-T6 ALUMINUM.

[4] FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK.

5. BREAK ALL SHARP EDGES.
6. INSTALL ALL FASTENERS WITH LOCKTITE.

[7] .2500-28UNF-3B OR
.2500-28UNJF-3B THDS
PER MIL-S-8879
.44 MIN COMPLETE THDS
CSK 90°-120° TO .260-.280 DIA

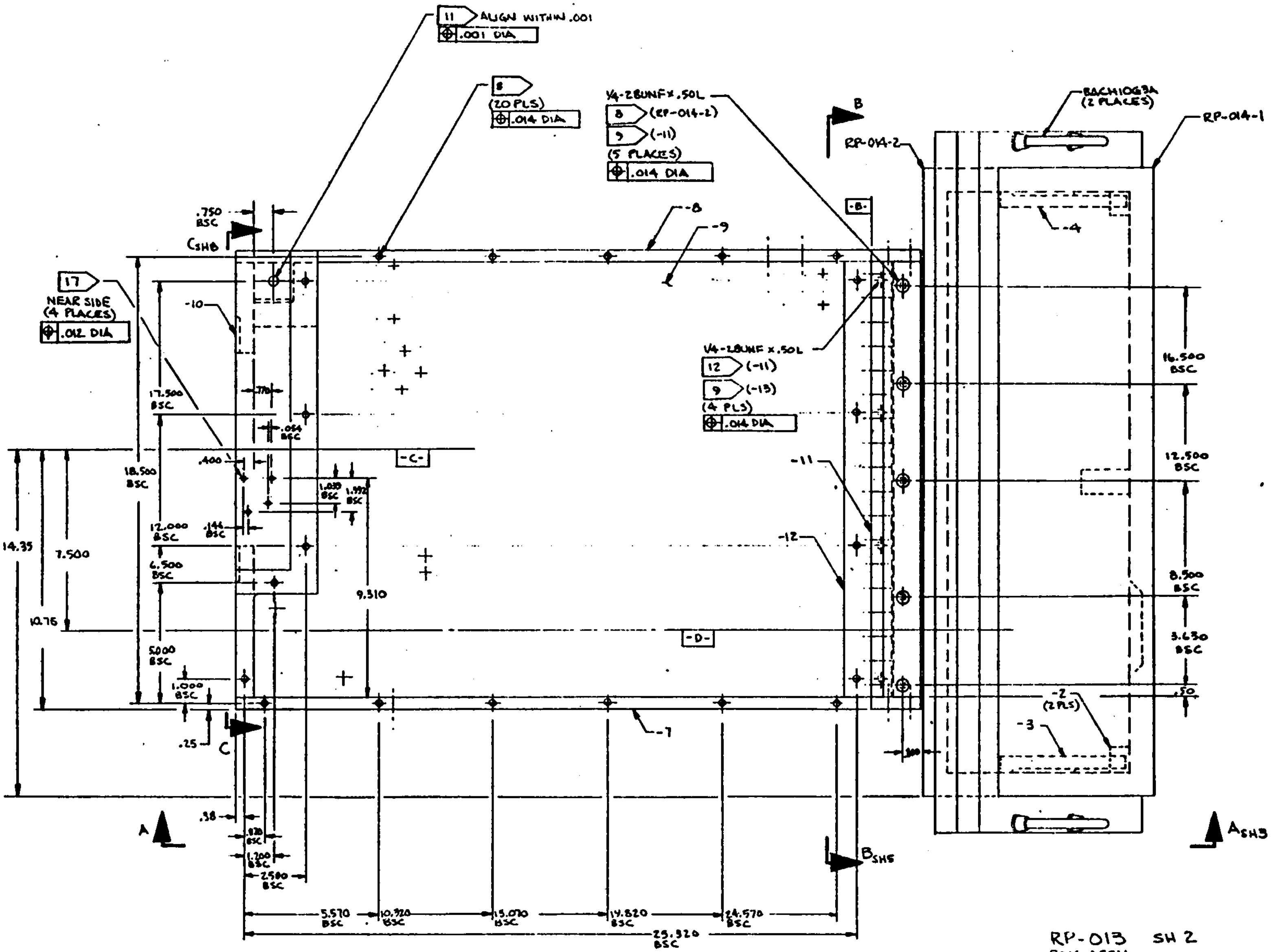
[8] .2500-28UNF-3B OR
.2500-28UNJF-3B THDS
PER MIL-S-8879
.44 MIN COMPLETE THDS
DRILL 1.00 MAX DEPTH
CSK 90°-120° TO .260-.280 DIA

	1	RP-014-2	WELDMENT	
	1	RP-014-1	WELDMENT	
	1	-12	SUPPORT	[3] [4] .875 THICK
	2	-11	CHANNEL	[3] [4] 1.75 THICK
	1	-10	FRONT PANEL	[3] [4] 3.25 THICK
	1	-9	BOTTOM PANEL	[3] [4] .50 THICK
	1	-8	OPP -7	
	1	-7	SIDE PANEL	[3] [4] .50 THICK
	1	-4	OPP-3	[3] [4] .625 THICK
	1	-3	GUARD	[3] [4] .625 THICK
	2	-2	BLOCK	[3] [4] .75 THICK
	—	-1	BOX ASSY	
	-1	PART NO.	NOMENCLATURE	REMARKS

RP-013 SH 1 OF 9
BOX ASSY

DWN: TK MATSUMOTO 11-15-81

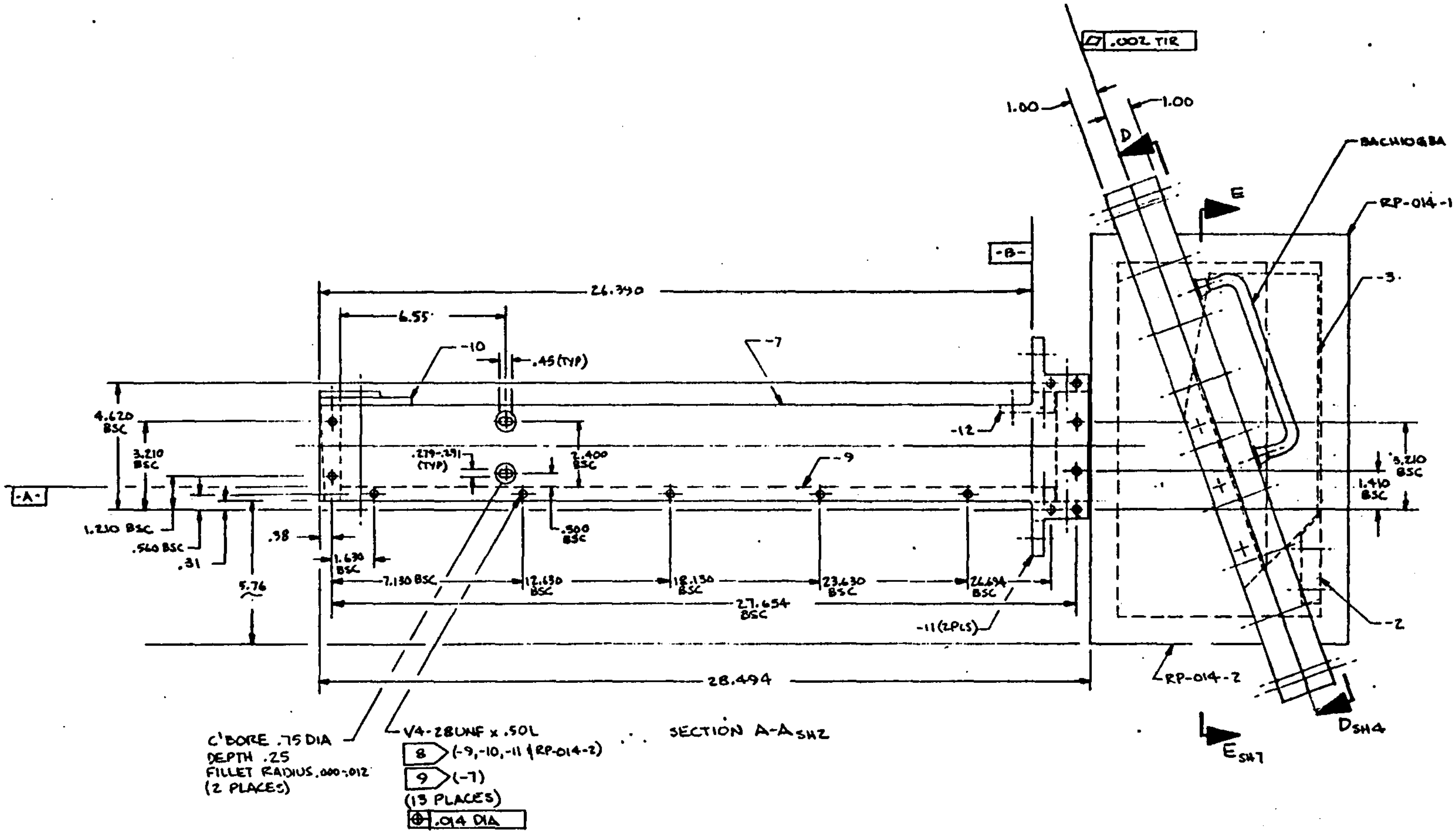
REV A 12/4/81
REV B 12/9/81
REV C 1/12/82
REV D 2/10/82



RP-013 SH 2
BOX ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11-13-81

REV A 12-2-81
REV B 12-4-81

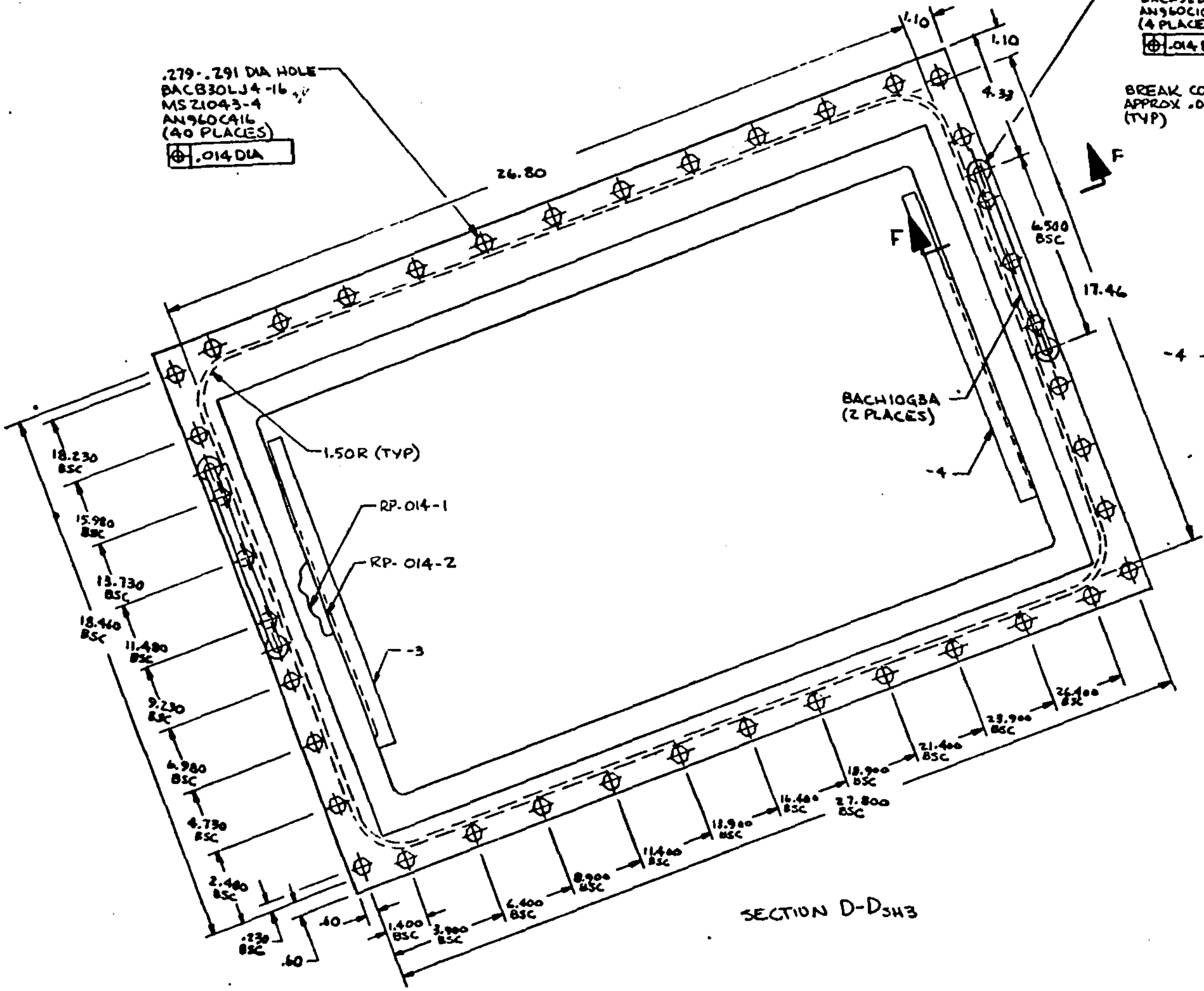
128



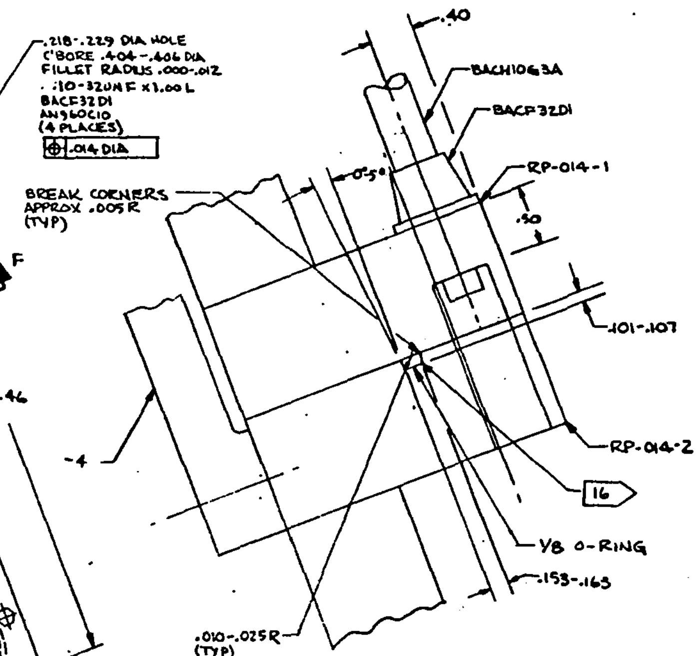
RP-013 SH 5
BOX ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11-13-81

REV A 12/3/81
REV D 3/10/82

129



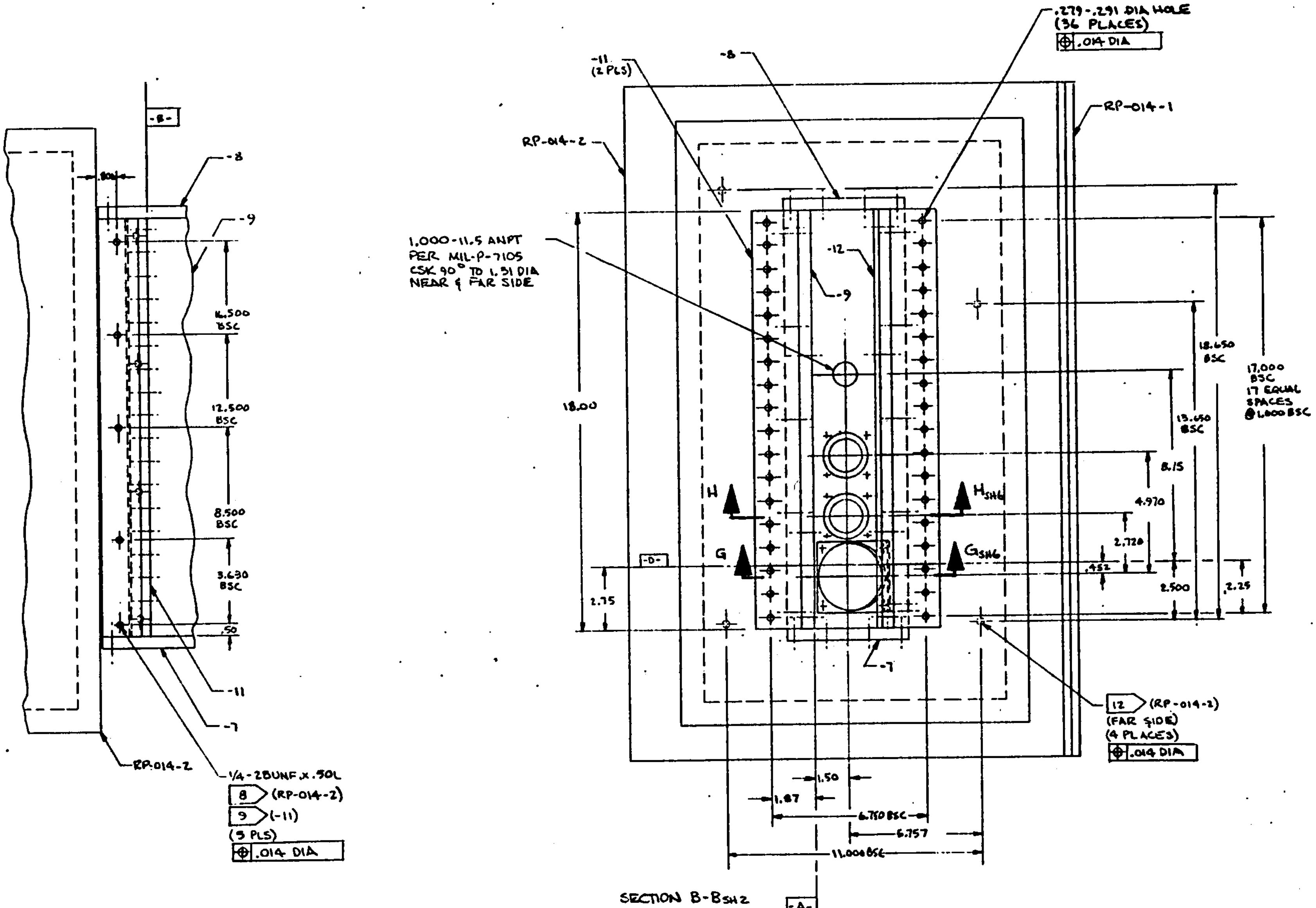
SECTION D-D SH3



SECTION F-F
SCALE: 1/1
TYPICAL O-RING GROOVE
GROOVE SURFACES 32

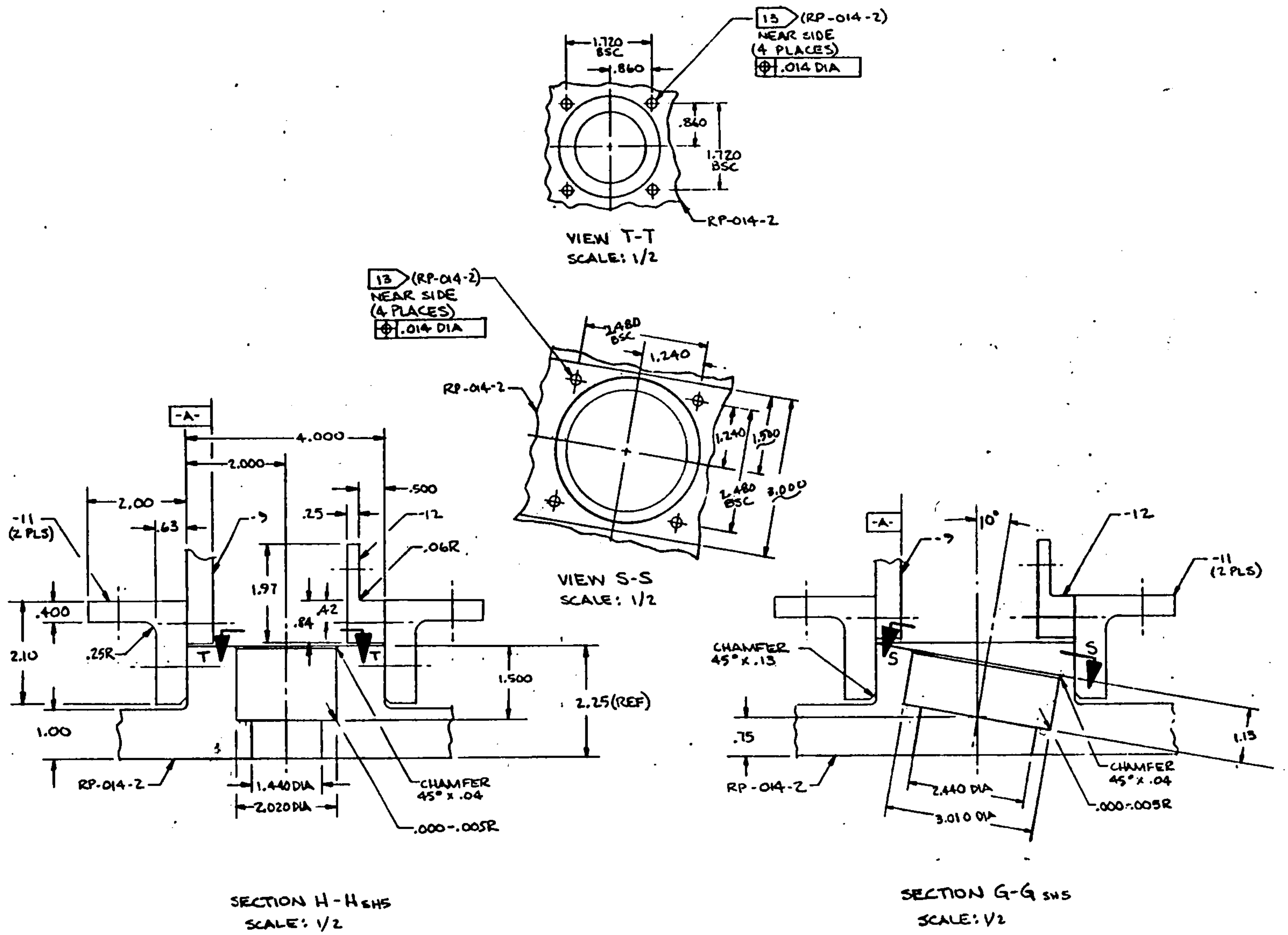
REV A 12/3/81

RP-013 SH 4
BOX ASSY
SCALE: 1/4
DWN: TK NATSUMOTO 11-13-81



RP-015 SH 5
BOX ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11-13-81

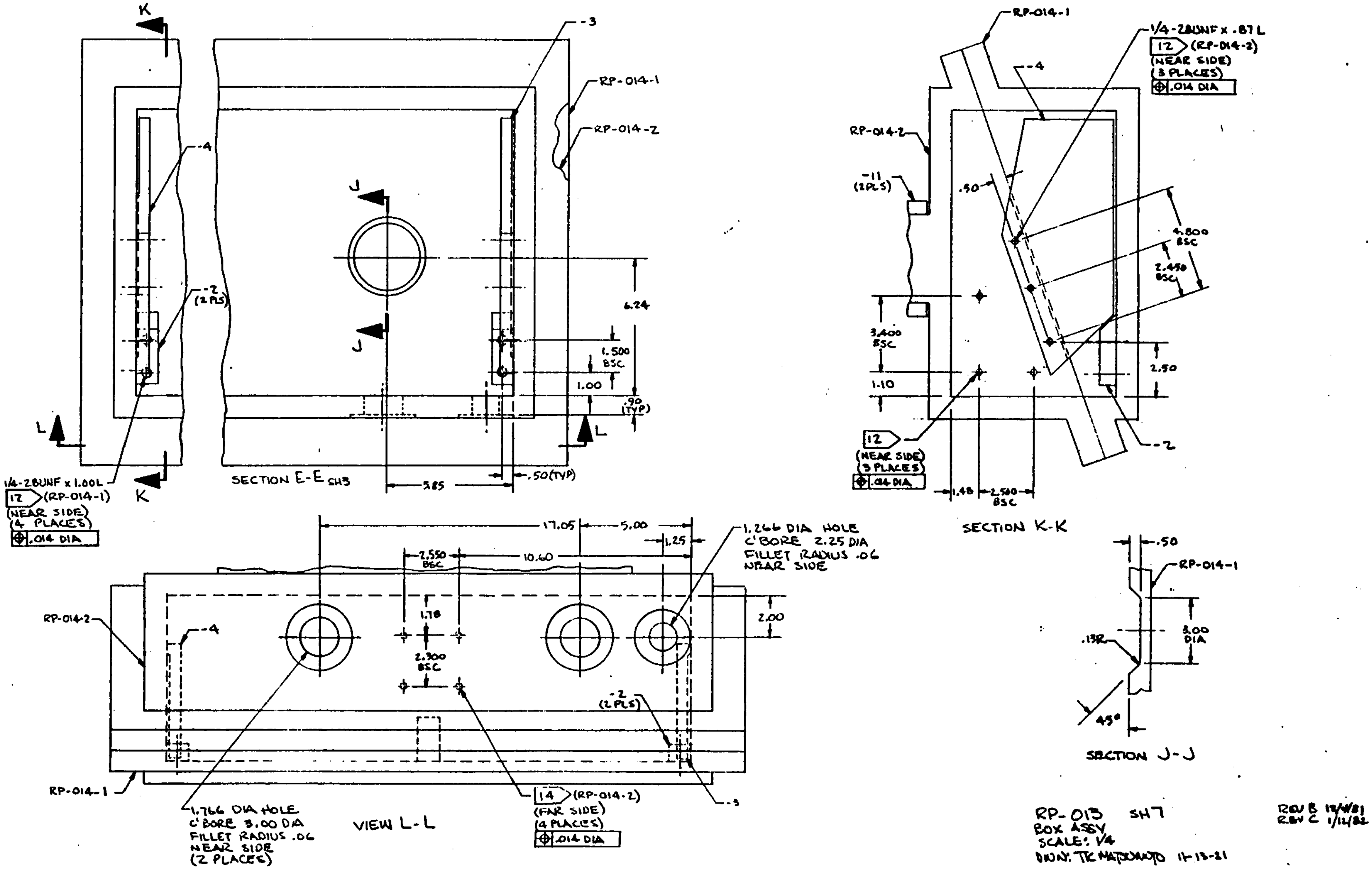
REV A
REV C
REV D



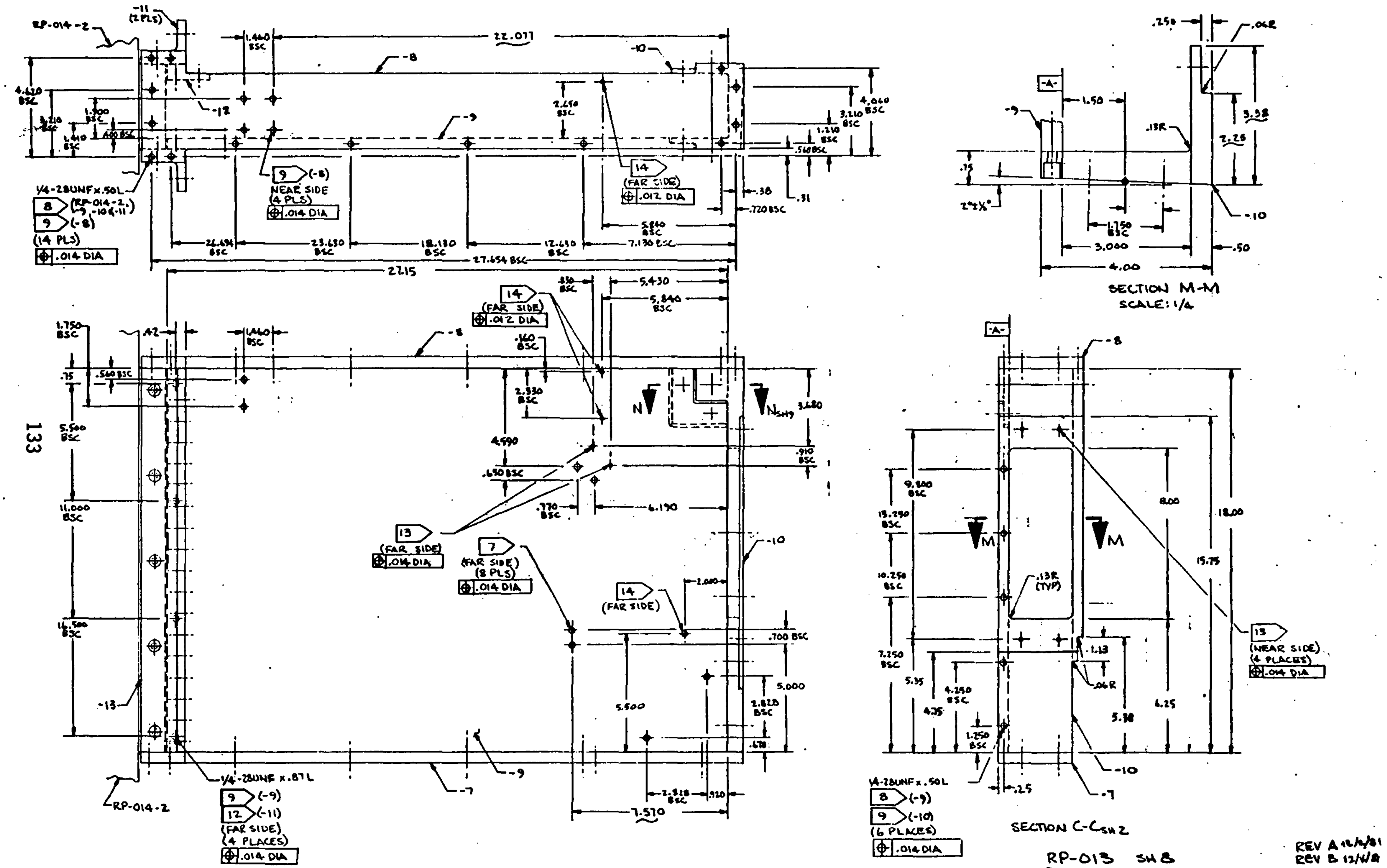
RP-013 SH6
BOX ASSY

DWN: TK MATSUMOTO 11-13-81

REV A 12/4/81


SECTION E-E SH3
-3
RP-014-1
RP-014-2
-4
-2 (2 PLS)
6.24
1.500 BSC
1.00
.90 (TYP)
3.85
.50 (TYP)
1/4-28UNF x 1.00L
12 (RP-014-1)
(NEAR SIDE)
(4 PLACES)
.014 DIA
SECTION K-K
RP-014-1
1/4-28UNF x .87 L
12 (RP-014-2)
(NEAR SIDE)
(3 PLACES)
.014 DIA
RP-014-2
-11 (2 PLS)
.50
4.800 BSC
2.450 BSC
3.400 BSC
1.10
2.50
12
(NEAR SIDE)
(3 PLACES)
.014 DIA
1.48
2.580 BSC
-2
VIEW L-L
17.05
5.00
1.25
2.550 BSC
10.60
1.266 DIA HOLE
C'BORE 2.25 DIA
FILLET RADIUS .06
NEAR SIDE
RP-014-2
-4
1.78
2.300 BSC
2.00
-2 (2 PLS)
RP-014-1
-3
1.766 DIA HOLE
C'BORE 3.00 DIA
FILLET RADIUS .06
NEAR SIDE
(2 PLACES)
14 (RP-014-2)
(FAR SIDE)
(4 PLACES)
.014 DIA
SECTION J-J
.50
RP-014-1
.13R
3.00 DIA
45°
RP-013 SH7
BOX ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11-13-81
REV B 12/4/81
REV C 1/12/82

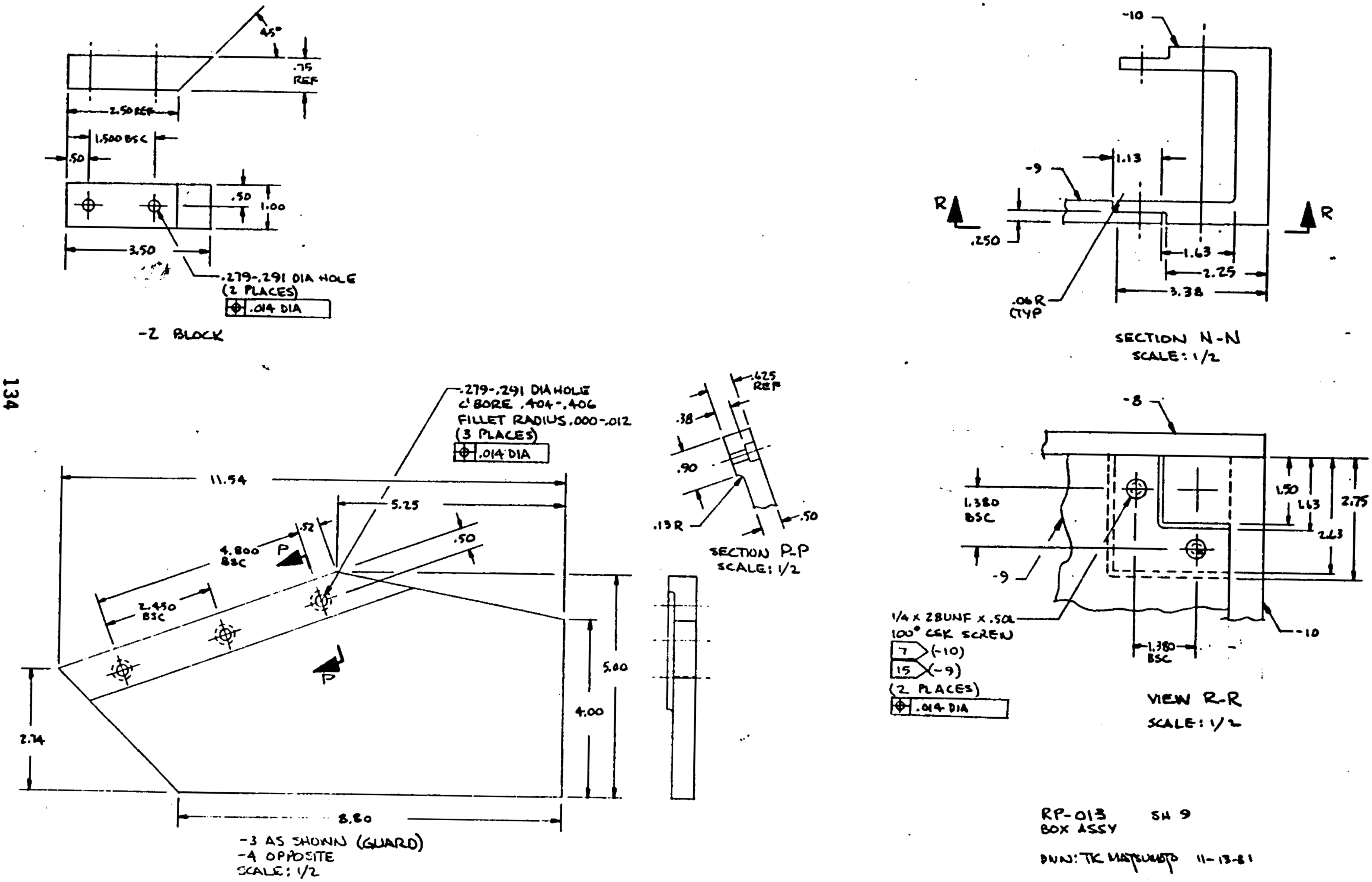
133



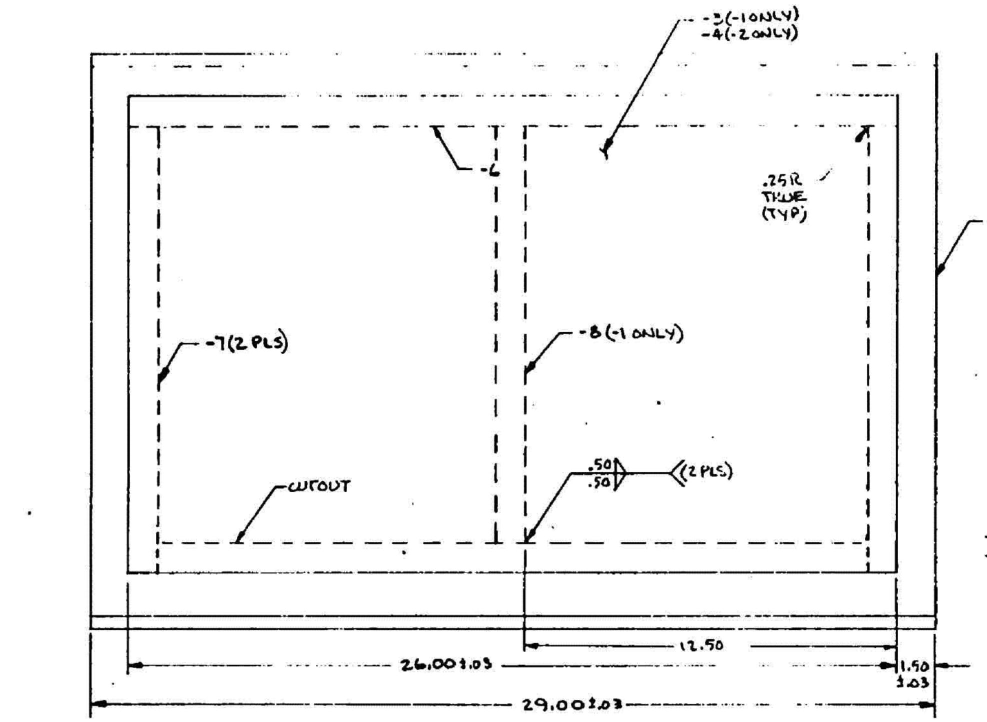
RP-013 SH 8
BOX ASSY

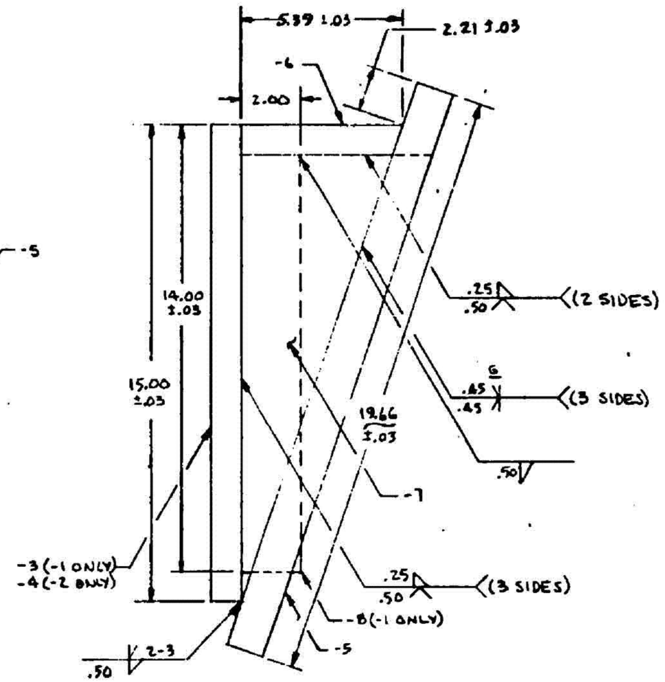
DWN: TK MATSUMOTO 11-13-81

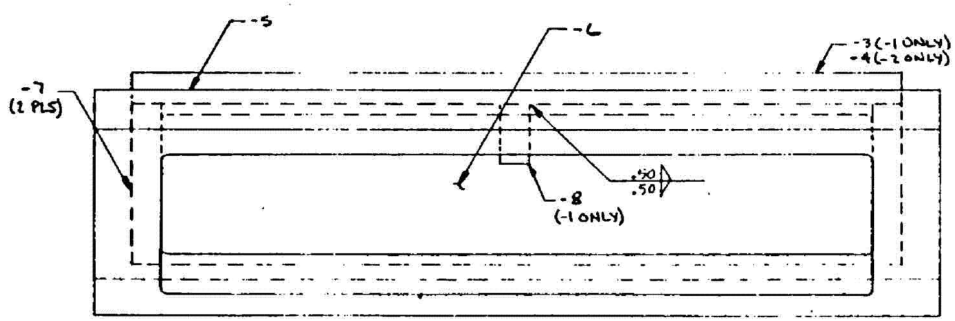
REV A 12/4/81
REV B 12/4/81


45°
.75 REF
2.50 REF
1.500 BSC
.50
.50
1.00
3.50
.279-.291 DIA HOLE (2 PLACES)
.014 DIA
-2 BLOCK
-10
1.13
-9
R
R
.250
1.63
2.25
3.38
.06R TYP
SECTION N-N SCALE: 1/2
.279-.291 DIA HOLE
C'BORE .404-.406
FILLET RADIUS .000-.012
(3 PLACES)
.014 DIA
11.54
5.25
.52
.50
4.800 BSC
P
2.450 BSC
P
5.00
4.00
2.74
8.80
-3 AS SHOWN (GUARD)
-4 OPPOSITE
SCALE: 1/2
.625 REF
.38
.90
.13R
.50
SECTION P-P SCALE: 1/2
-8
1.380 BSC
1.50
1.63
2.75
2.63
-9
-10
1/4 x 28UNF x .50L
100° CSK SCREW
7 (-10)
15 (-9)
(2 PLACES)
.014 DIA
1.380 BSC
VIEW R-R SCALE: 1/2
RP-013 SH 9
BOX ASSY
DWN: TK MATSUMOTO 11-13-81

NOTES:
1. WELD PER BAC 5975 CLASS A. FILLER METAL ER4043 OR 4043
2. 125 ALL MACHINED SURFACES





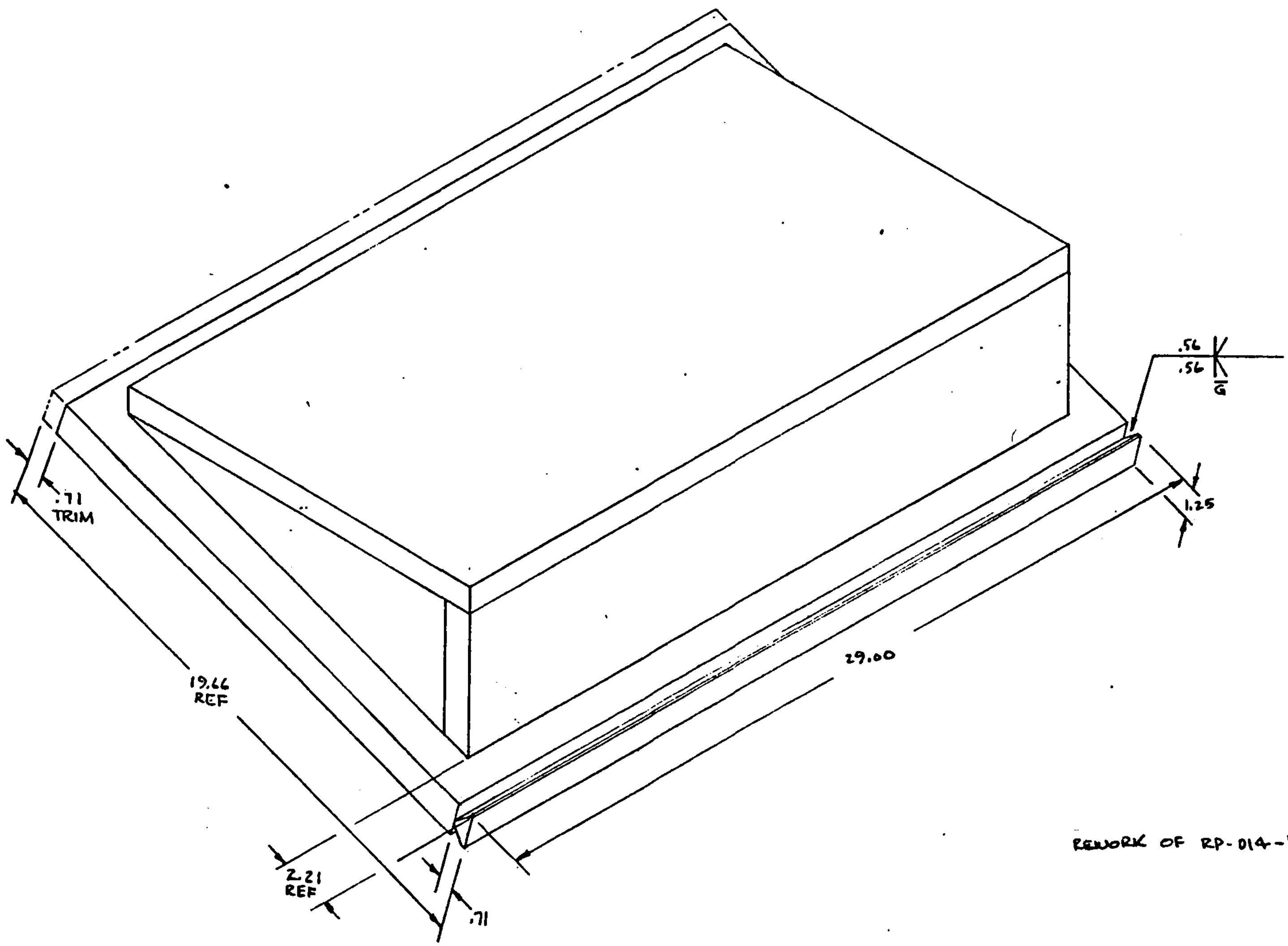


-1 & -2 WELDMENT

-2	-1	PART NO.	NOMENCLATURE	REMARKS
	1	-8	STIFFENER	MATERIAL: 6061-T6 AL PLATE 1.0 THICK
2	2	-7	SIDE	MATERIAL: 6061-T6 AL PLATE 1.0 THICK
1	1	-6	SIDE	MATERIAL: 6061-T6 AL PLATE 1.0 THICK
1	1	-5	FLANGE	MATERIAL: 6061-T6 AL PLATE 1.25 THICK
1		-4	TOP	MATERIAL: 6061-T6 AL PLATE 2.25 THICK
	1	-3	TOP	MATERIAL: 6061-T6 AL PLATE 1.00 THICK
-		-2	WELDMENT	
	-	-1	WELDMENT	

RP-014 SH 1
WELDMENT
SCALE: 1/4
DWN: TK MATSUMOTO 10-30-81

REV A 11/25/81



REWORK OF RP-014-1

			1		POWER SUPPLY	
			1	CAT#85-15-2120	POWER SUPPLY	SOLA ELECTRIC
			1	RP-013-1	BOX ASSY	
			1	RP-012-1	LASER SOURCE ASSY	
			12	10-32UNF x 5/8L	CAP SCREW	CRES 304
			1	1/4-28UNF x 1 7/16L	CAP SCREW	CRES 304
			3	1/4-28UNF x 1 1/4L	CAP SCREW	CRES 304
			6	1/4-28UNF x 7/8L	CAP SCREW	CRES 304
			28	1/4-28UNF x 1/2L	CAP SCREW	CRES 304
			4	10-32UNF x 3/4L	CAP SCREW	CRES 304
			2	10-32UNF x 1/4L	CAP SCREW	CRES 304
			4	6-32UNC x 1 1/2L	CAP SCREW	CRES 304
			4	6-32UNC x 1/4L	CAP SCREW	CRES 304
			11	4-40UNC x 3/8L	CAP SCREW	CRES 304
			4	1/4-28UNF x 1/2L	SCREW, 100° HD	CRES 304
	2	2		R6FF	BEARING	TRW
			1	MS21043-4	NUT	
			1	3/16 DIA x 3/4 LONG	DOWEL PIN	
			1	3/8 DIA x 1 5/8 LONG	DOWEL PIN	
			1	3/8 DIA x 4.0 LONG	DOWEL PIN	
			1	1/2 DIA x 2 3/4 LONG	DOWEL PIN	
			1	MPD-6405-6	ACTUATOR	DUFF-NORTON
			1		O-RING	2 5/8 I.D.
			1		O-RING	1 5/8 I.D.
			2	6-32UNC x 1/8L NYLON	NYLON SCREW	
			4	4-40UNC x 3/8L	CAP SCREW	CRES 304
			1	-31	REF MIRROR HOLDER	3 4
			1	-30	REF REFLECTOR MOUNT	3 4
			1	-29	LENS MOUNT	3 4
			1	-28	LENS	
			1	-27	LENS	
			2	-26	GASKET	17
			1	-25	GASKET	17
			1	-24	COVER	3 4
	1			-23	ADAPTER	3 4
	—		1	-22	ADAPTER	
			1	-21	PLUG	3 4
	-22	-2	-1	PART NO.	NOMENCLATURE	REMARKS

13 .1380-32UNC-3B THDS
PER MIL-S-8879
CSK 90°-120° TO .150-.180 DIA
.25 MIN COMPLETE THDS.

14 .2500-28UNF-3B THDS
PER MIL-S-8879
CSK 90°-120° TO .260-.280 DIA
.44 MIN COMPLETE THDS

15 MATERIAL: 6061-T4 ALUMINUM.

16 .1120-40UNC-3B THDS
PER MIL-S-8879
.25 MIN COMPLETE THDS
CSK 90°-120° TO .120-.140 DIA

17 INSTALL GASKET USING PTFE .060 THICK.

18 3/16 DIA x .75 LONG DOWEL PIN INTERFERENCE FIT TO BE LOCATED AFTER ADJUSTMENT.

19 TO MATCH -7 LENS WITH .010 GAP ON ALL SURFACES.

NOTES:

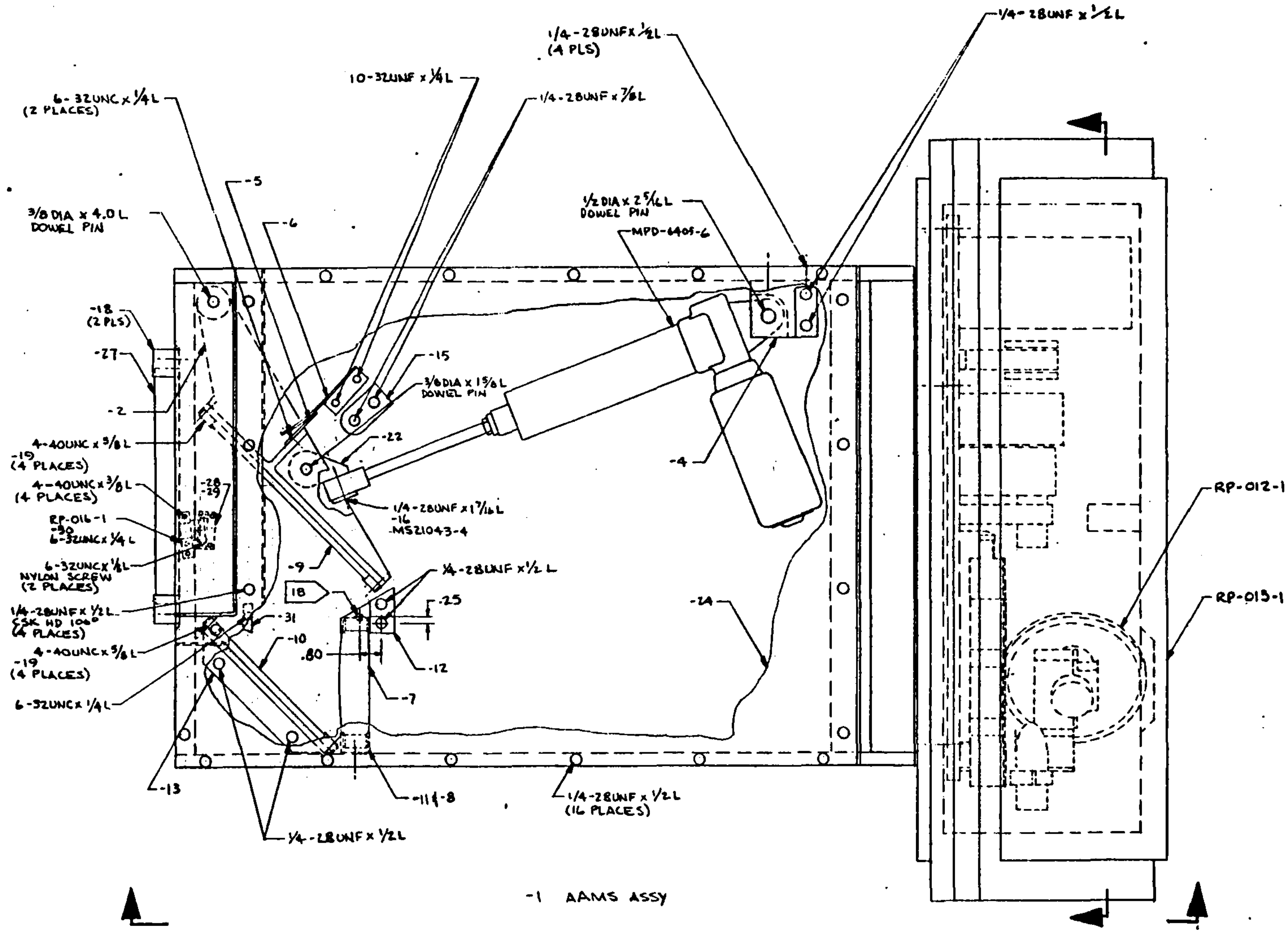
1. TOLERANCES:
   .XX ±.03
   .XXX ±.010
   ANGLE ±1°
2. 63/ ALL MACHINED SURFACES (EXCEPT AS NOTED)
3. MATERIAL: 6061-T6 ALUMINUM
4. FINISH PER BAC5884, TYPE II, CLASS 2, COLOR BLACK.
5. BREAK ALL SHARP EDGES.
6. ALL FILLET RADIUS .06 (EXCEPT AS NOTED)
7. INSTALL ALL FASTENERS WITH LOCKTITE
8. PRESS FIT TO MATCH R6FF BEARING .875 DIA REF.
9. PRESS FIT TO MATCH MPD-6405-6 ACTUATOR .500 DIA REF.
10. WIDTH OF CAVITY IN THIS AREA TO BE WITHIN .010
11. ALIGNMENT BETWEEN BUSHINGS TO BE WITHIN .001.
12. PRESS FIT TO MATCH 1/2 DIA DOWEL PIN. ALIGNMENT WITHIN .001

			2	-20	PLUG	3 4
			8	-19	RETAINER	3 4
			2	-18	RETAINER	3 4
			4	-17	RETAINER	3 4
			3	-16	WASHER	3 4
			1	-15	STOPPER	3 4
			1	-14	SPACER	3 4
			1	-13	ANGLE	3 4
			1	-12	BRACKET	3 4
			1	-11	BRACKET	3 4
			1	-10	MIRROR	
			1	-9	MIRROR	
			A/R	-8	SHIM	
			1	-7	LENS	
			1	-6	BAFFLE	15 4
			1	5	BAFFLE	15 4
			1	-4	BRACKET	3 4
		1		-3	BRACKET	3 4
		—	1	-2	BRACKET	
			—	-1		
		-2	-1	PART NO.	NOMENCLATURE	REMARKS

RP-015 SH 1 OF 9
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY

REV A 12/9/81
REV B 1/25/82

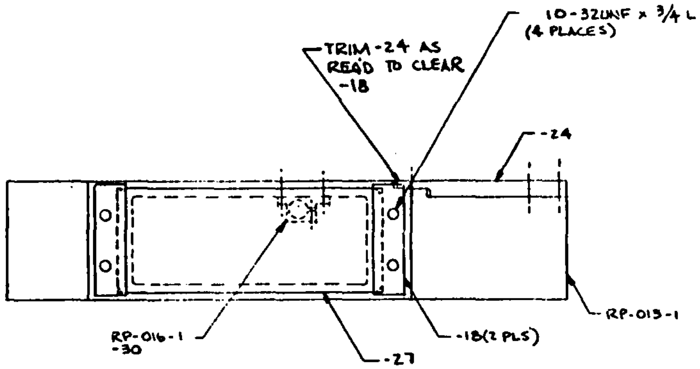
DWN: TK MATSUMOTO 11/25/81

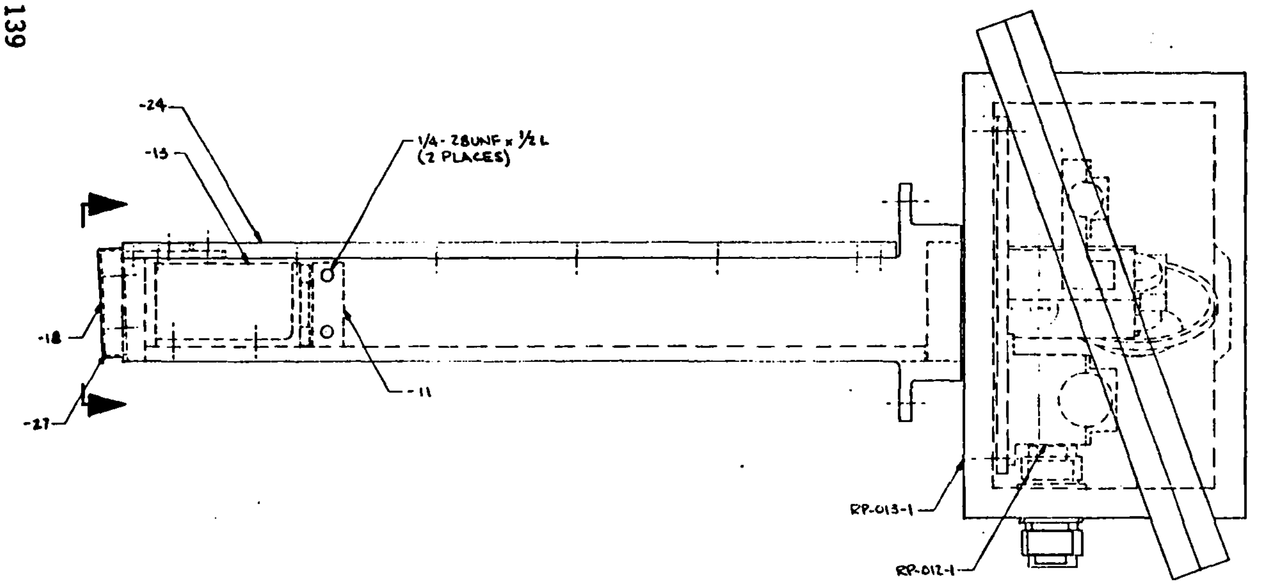


-1 AAMS ASSY

RP-015 SH 2
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11/25/81

REV A 12/1/81
REV B 1/25/82

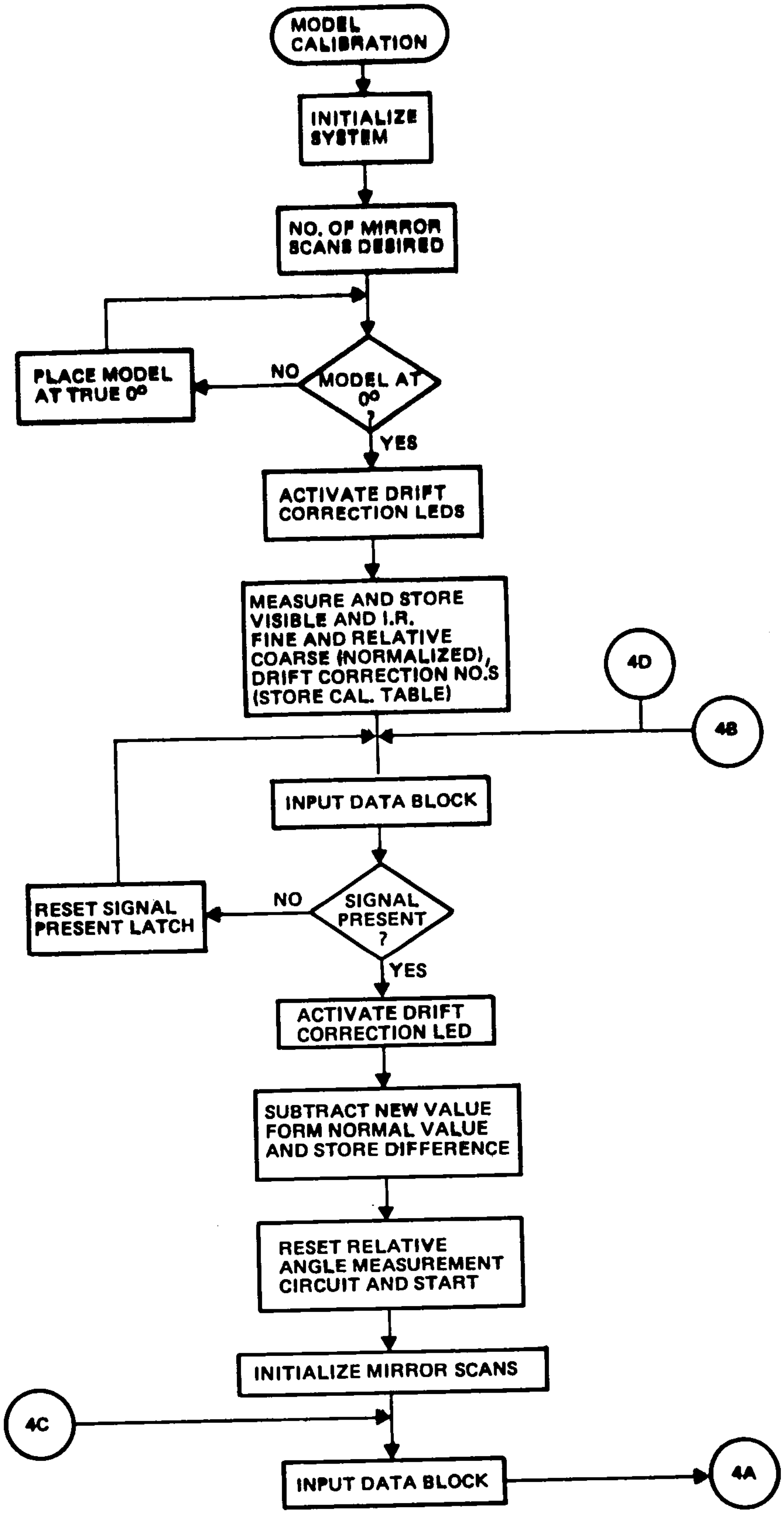


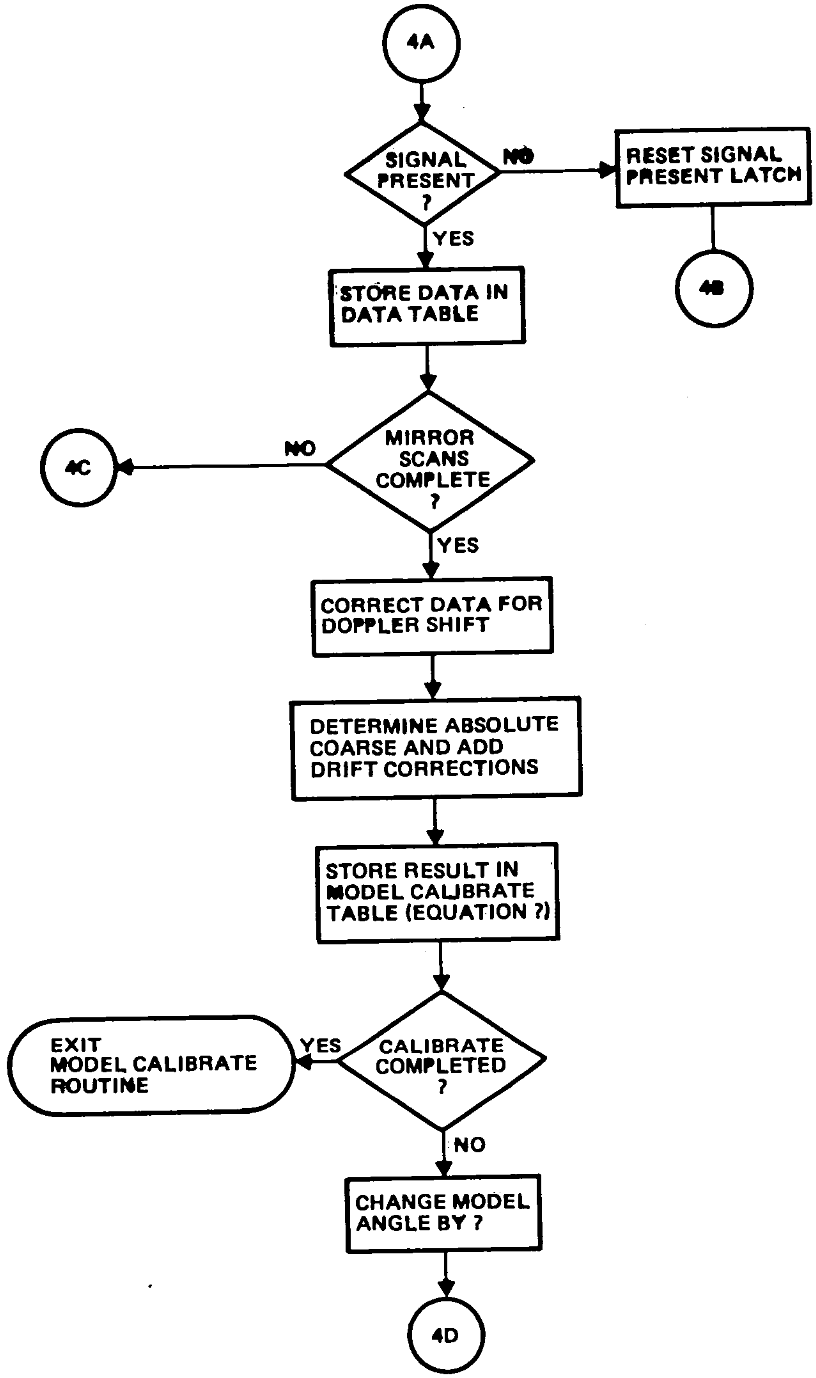


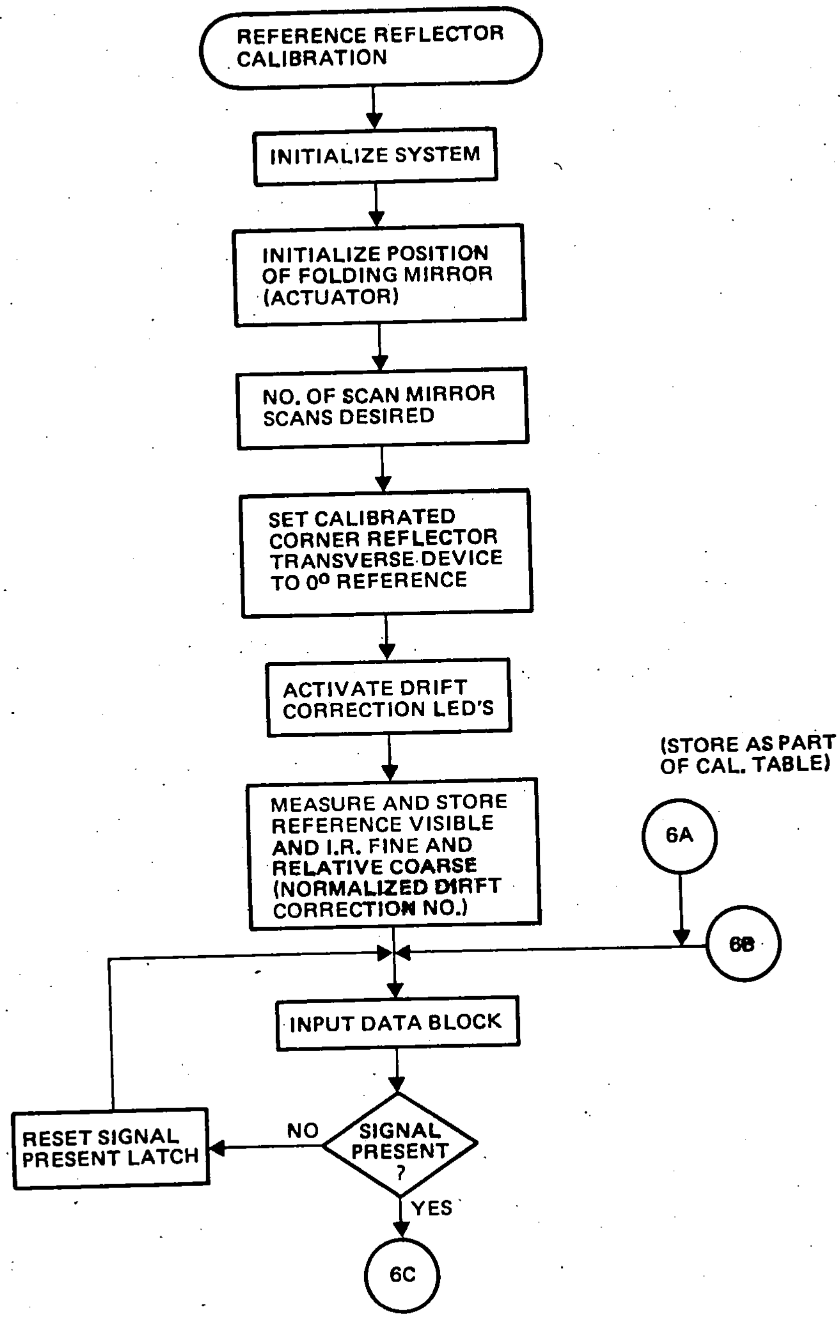
RP-015 SH 3
ABSOLUTE ANGLE MEASUREMENT
SYSTEM ASSY
SCALE: 1/4
DWN: TK MATSUMOTO 11/25/81

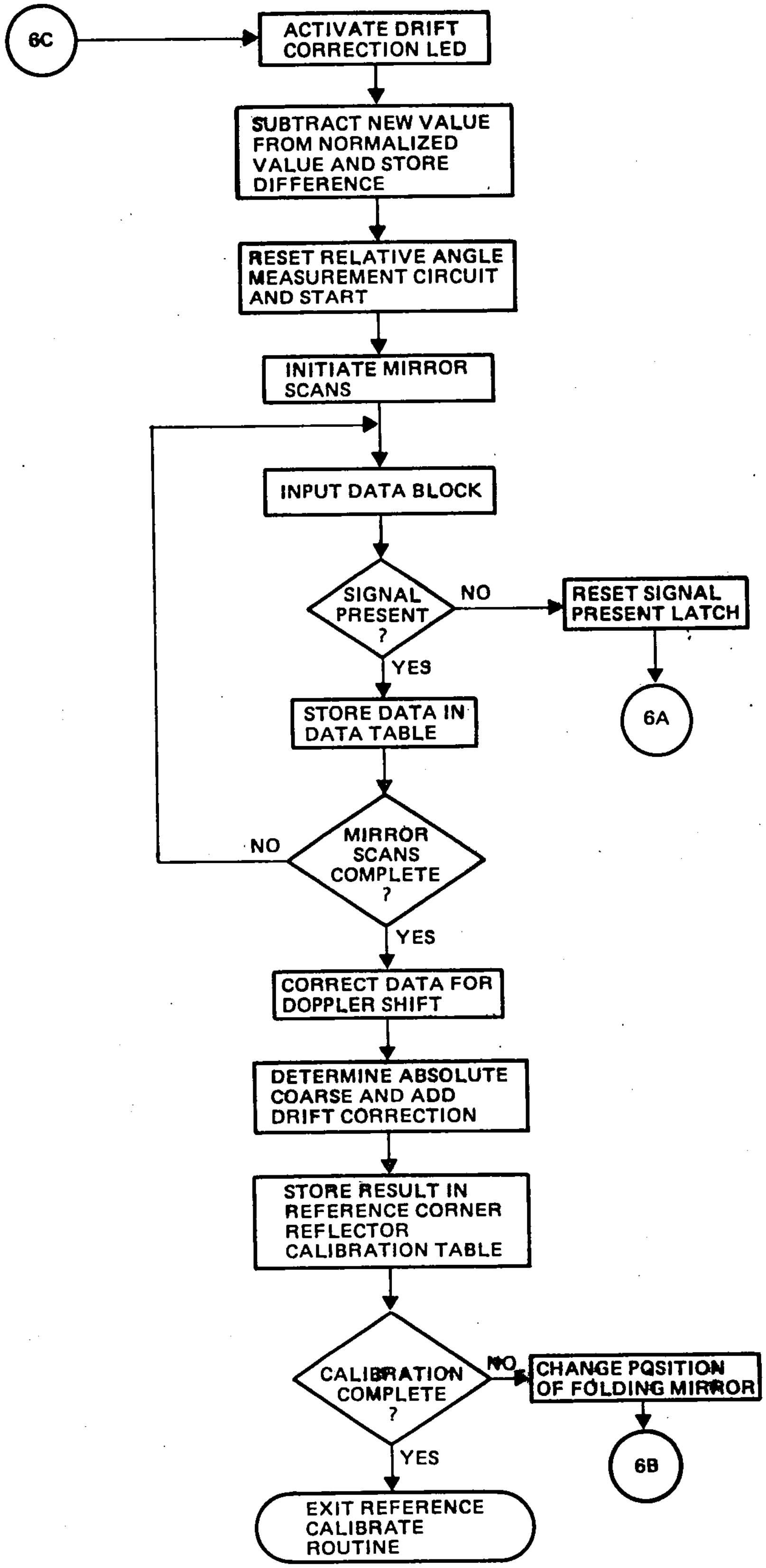
REV A 1/4/81
REV B 1/25/82

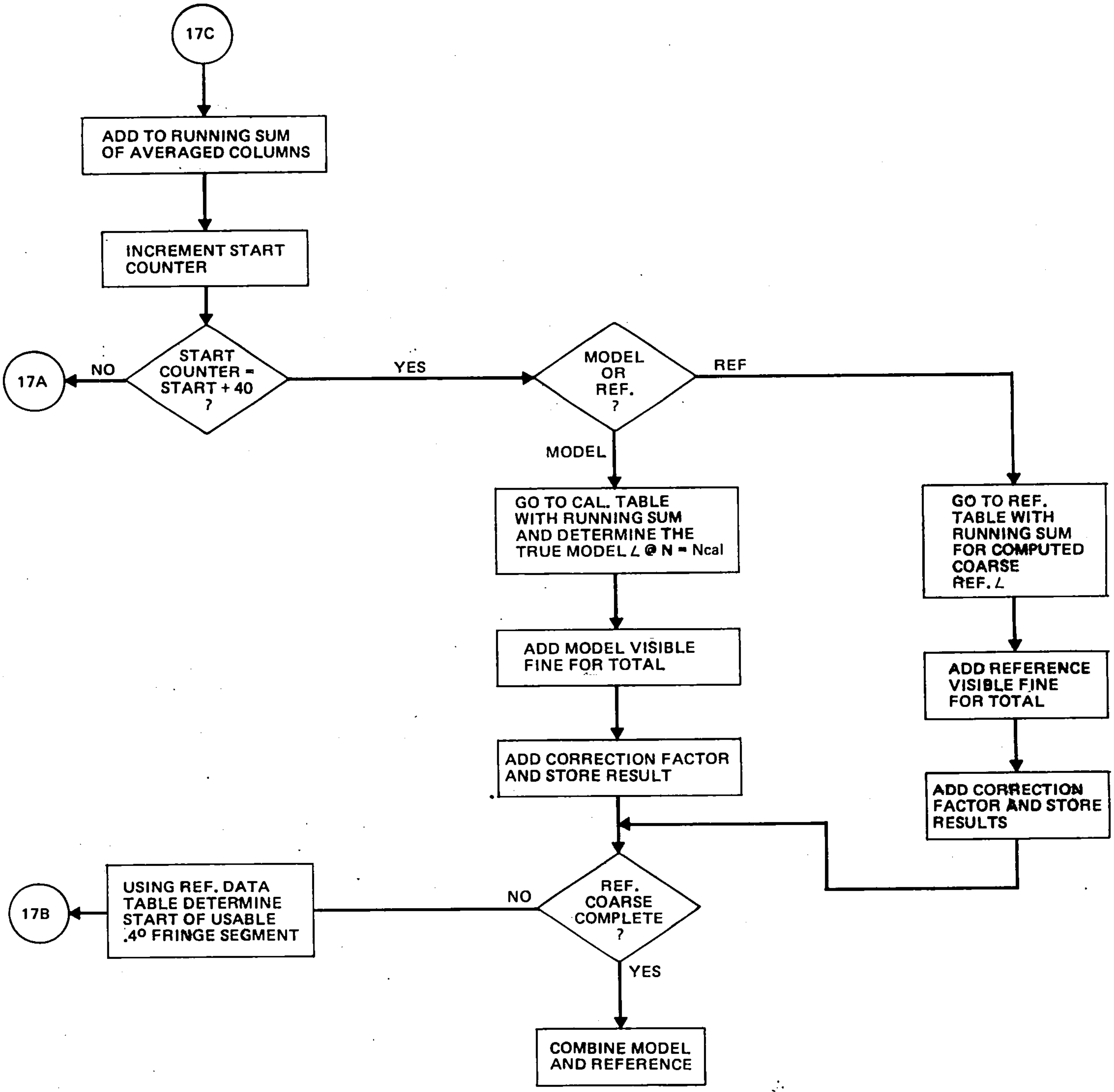
VI. DATA PROCESSING FLOW CHARTS

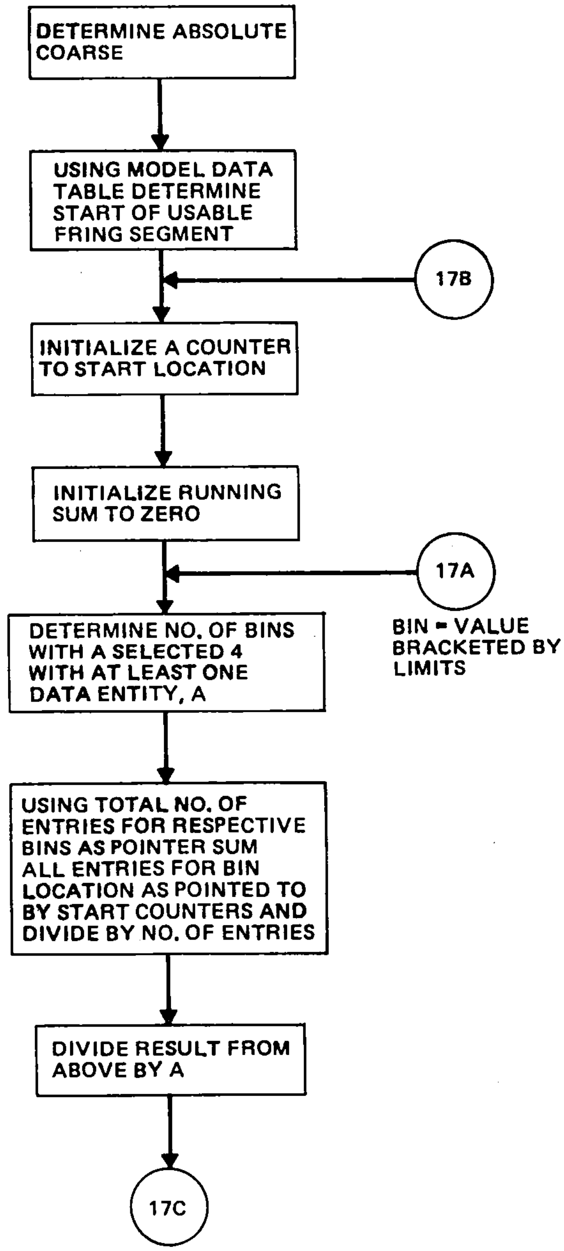

MODEL CALIBRATION
INITIALIZE SYSTEM
NO. OF MIRROR SCANS DESIRED
MODEL AT 0° ?
NO
PLACE MODEL AT TRUE 0°
YES
ACTIVATE DRIFT CORRECTION LEDS
MEASURE AND STORE VISIBLE AND I.R. FINE AND RELATIVE COARSE (NORMALIZED), DRIFT CORRECTION NO.S (STORE CAL. TABLE)
4D
4B
INPUT DATA BLOCK
SIGNAL PRESENT ?
NO
RESET SIGNAL PRESENT LATCH
YES
ACTIVATE DRIFT CORRECTION LED
SUBTRACT NEW VALUE FORM NORMAL VALUE AND STORE DIFFERENCE
RESET RELATIVE ANGLE MEASUREMENT CIRCUIT AND START
INITIALIZE MIRROR SCANS
4C
INPUT DATA BLOCK
4A

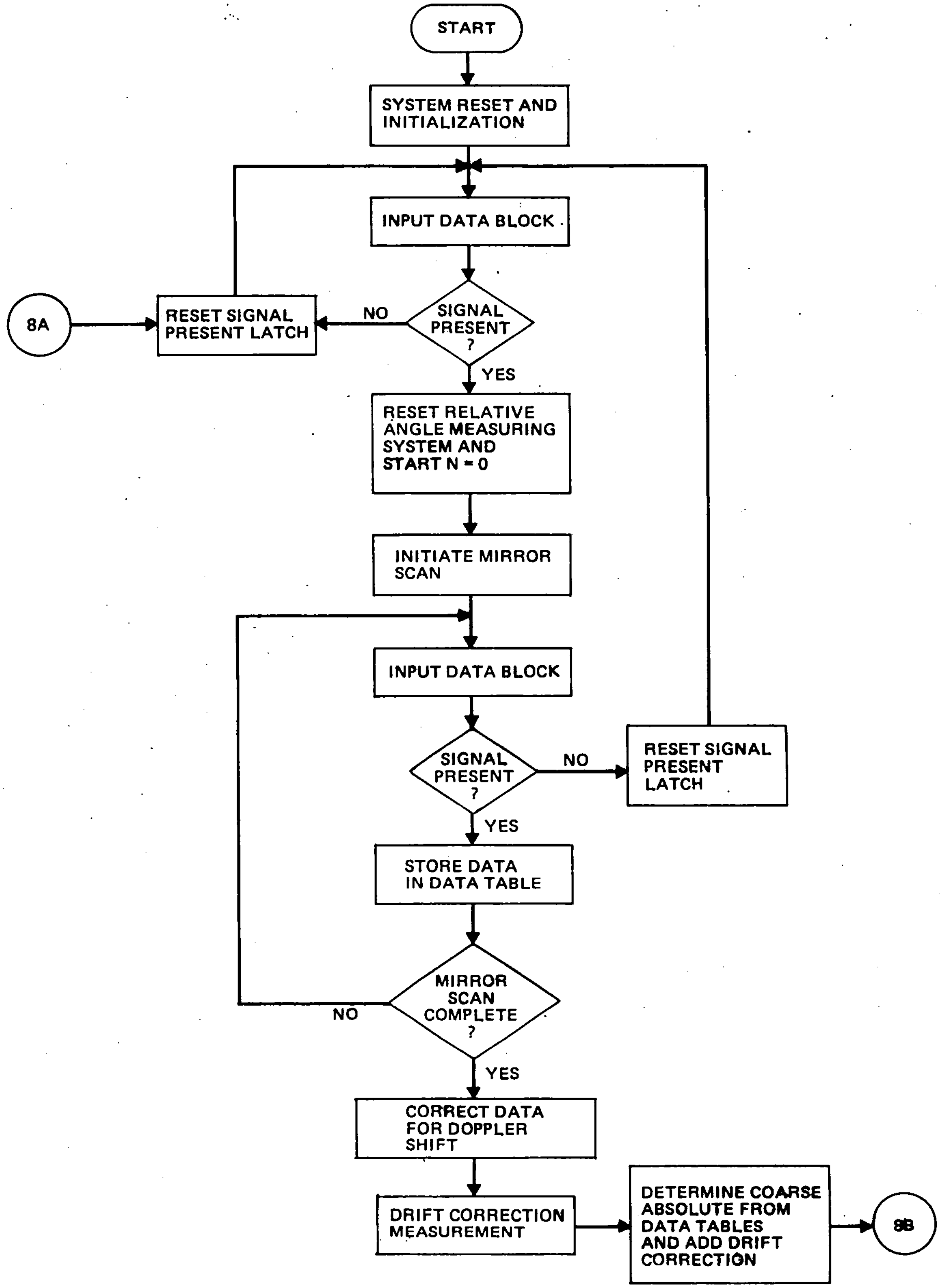

4A
SIGNAL PRESENT ?
NO
RESET SIGNAL PRESENT LATCH
4B
YES
STORE DATA IN DATA TABLE
MIRROR SCANS COMPLETE ?
NO
4C
YES
CORRECT DATA FOR DOPPLER SHIFT
DETERMINE ABSOLUTE COARSE AND ADD DRIFT CORRECTIONS
STORE RESULT IN MODEL CALIBRATE TABLE (EQUATION ?)
CALIBRATE COMPLETED ?
YES
EXIT MODEL CALIBRATE ROUTINE
NO
CHANGE MODEL ANGLE BY ?
4D

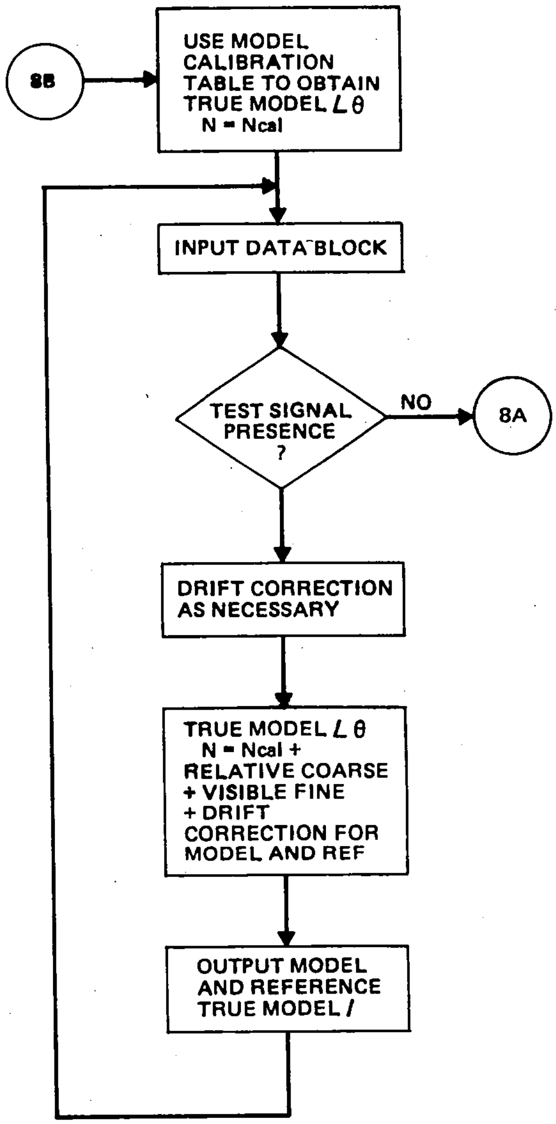

REFERENCE REFLECTOR CALIBRATION
INITIALIZE SYSTEM
INITIALIZE POSITION OF FOLDING MIRROR (ACTUATOR)
NO. OF SCAN MIRROR SCANS DESIRED
SET CALIBRATED CORNER REFLECTOR TRANSVERSE DEVICE TO 0° REFERENCE
ACTIVATE DRIFT CORRECTION LED'S
MEASURE AND STORE REFERENCE VISIBLE AND I.R. FINE AND RELATIVE COARSE (NORMALIZED DIRFT CORRECTION NO.)
(STORE AS PART OF CAL. TABLE)
6A
6B
INPUT DATA BLOCK
SIGNAL PRESENT ?
NO
YES
RESET SIGNAL PRESENT LATCH
6C

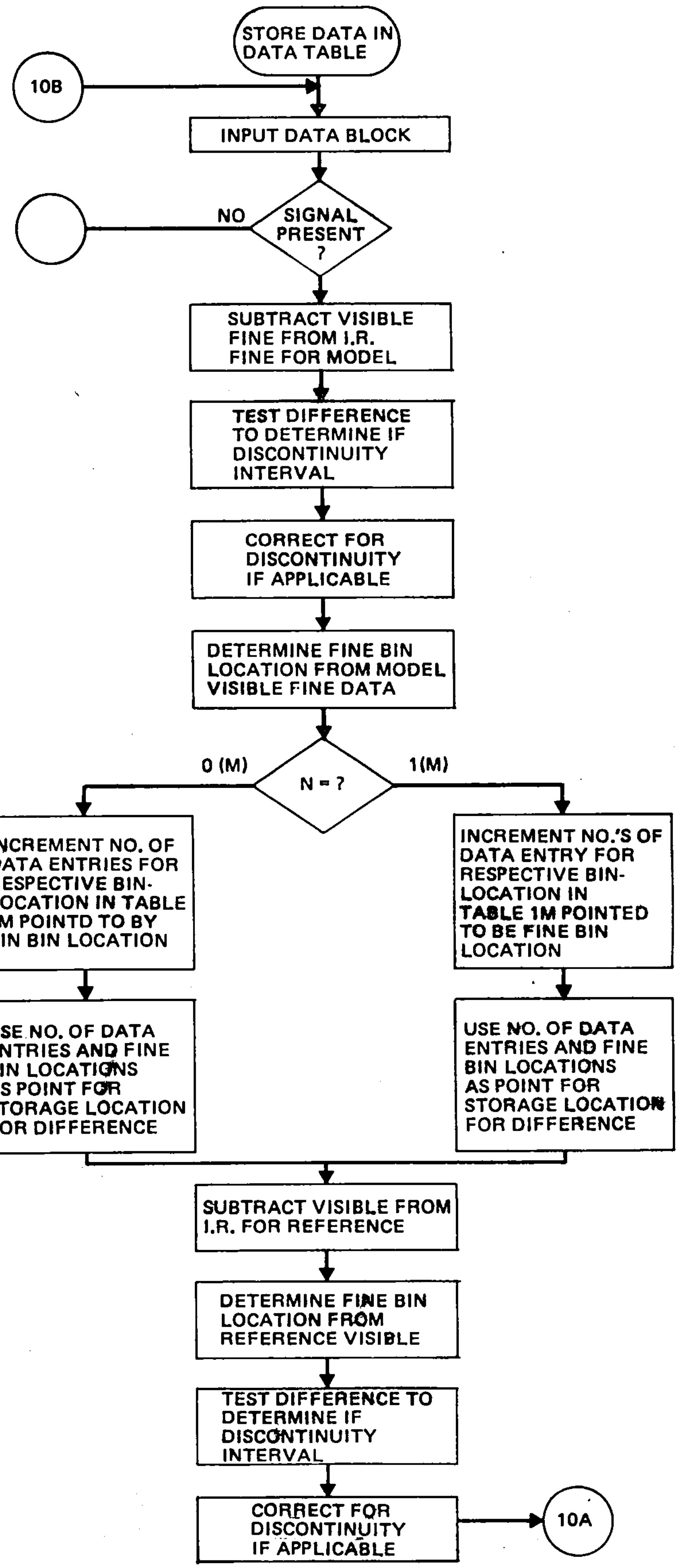

6C
ACTIVATE DRIFT CORRECTION LED
SUBTRACT NEW VALUE FROM NORMALIZED VALUE AND STORE DIFFERENCE
RESET RELATIVE ANGLE MEASUREMENT CIRCUIT AND START
INITIATE MIRROR SCANS
INPUT DATA BLOCK
SIGNAL PRESENT ?
NO
RESET SIGNAL PRESENT LATCH
6A
YES
STORE DATA IN DATA TABLE
MIRROR SCANS COMPLETE ?
NO
YES
CORRECT DATA FOR DOPPLER SHIFT
DETERMINE ABSOLUTE COARSE AND ADD DRIFT CORRECTION
STORE RESULT IN REFERENCE CORNER REFLECTOR CALIBRATION TABLE
CALIBRATION COMPLETE ?
NO
CHANGE POSITION OF FOLDING MIRROR
6B
YES
EXIT REFERENCE CALIBRATE ROUTINE

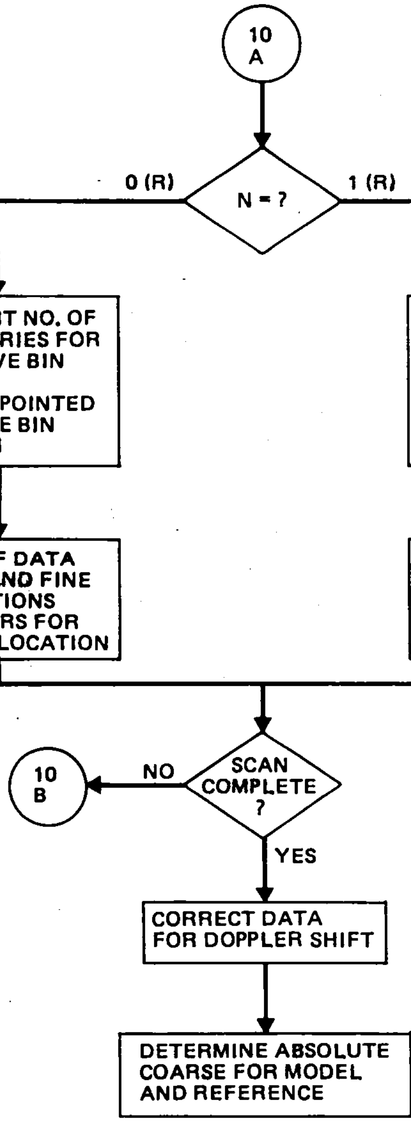

17C
ADD TO RUNNING SUM OF AVERAGED COLUMNS
INCREMENT START COUNTER
START COUNTER = START + 40 ?
NO
17A
YES
MODEL OR REF. ?
REF
MODEL
GO TO CAL. TABLE WITH RUNNING SUM AND DETERMINE THE TRUE MODEL ∠ @ N = Ncal
ADD MODEL VISIBLE FINE FOR TOTAL
ADD CORRECTION FACTOR AND STORE RESULT
GO TO REF. TABLE WITH RUNNING SUM FOR COMPUTED COARSE REF. ∠
ADD REFERENCE VISIBLE FINE FOR TOTAL
ADD CORRECTION FACTOR AND STORE RESULTS
REF. COARSE COMPLETE ?
NO
USING REF. DATA TABLE DETERMINE START OF USABLE .4° FRINGE SEGMENT
17B
YES
COMBINE MODEL AND REFERENCE

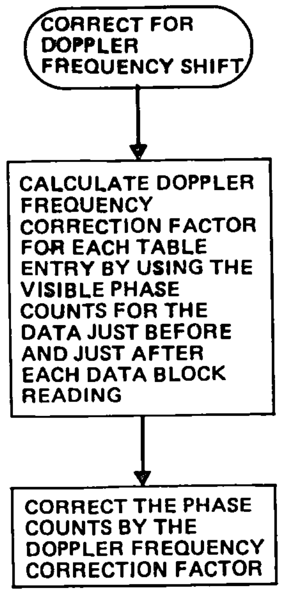

DETERMINE ABSOLUTE COARSE
USING MODEL DATA TABLE DETERMINE START OF USABLE FRING SEGMENT
17B
INITIALIZE A COUNTER TO START LOCATION
INITIALIZE RUNNING SUM TO ZERO
17A
BIN = VALUE BRACKETED BY LIMITS
DETERMINE NO. OF BINS WITH A SELECTED 4 WITH AT LEAST ONE DATA ENTITY, A
USING TOTAL NO. OF ENTRIES FOR RESPECTIVE BINS AS POINTER SUM ALL ENTRIES FOR BIN LOCATION AS POINTED TO BY START COUNTERS AND DIVIDE BY NO. OF ENTRIES
DIVIDE RESULT FROM ABOVE BY A
17C


START
SYSTEM RESET AND INITIALIZATION
INPUT DATA BLOCK
SIGNAL PRESENT ?
NO
YES
8A
RESET SIGNAL PRESENT LATCH
RESET RELATIVE ANGLE MEASURING SYSTEM AND START N = 0
INITIATE MIRROR SCAN
INPUT DATA BLOCK
SIGNAL PRESENT ?
NO
RESET SIGNAL PRESENT LATCH
YES
STORE DATA IN DATA TABLE
MIRROR SCAN COMPLETE ?
NO
YES
CORRECT DATA FOR DOPPLER SHIFT
DRIFT CORRECTION MEASUREMENT
DETERMINE COARSE ABSOLUTE FROM DATA TABLES AND ADD DRIFT CORRECTION
8B

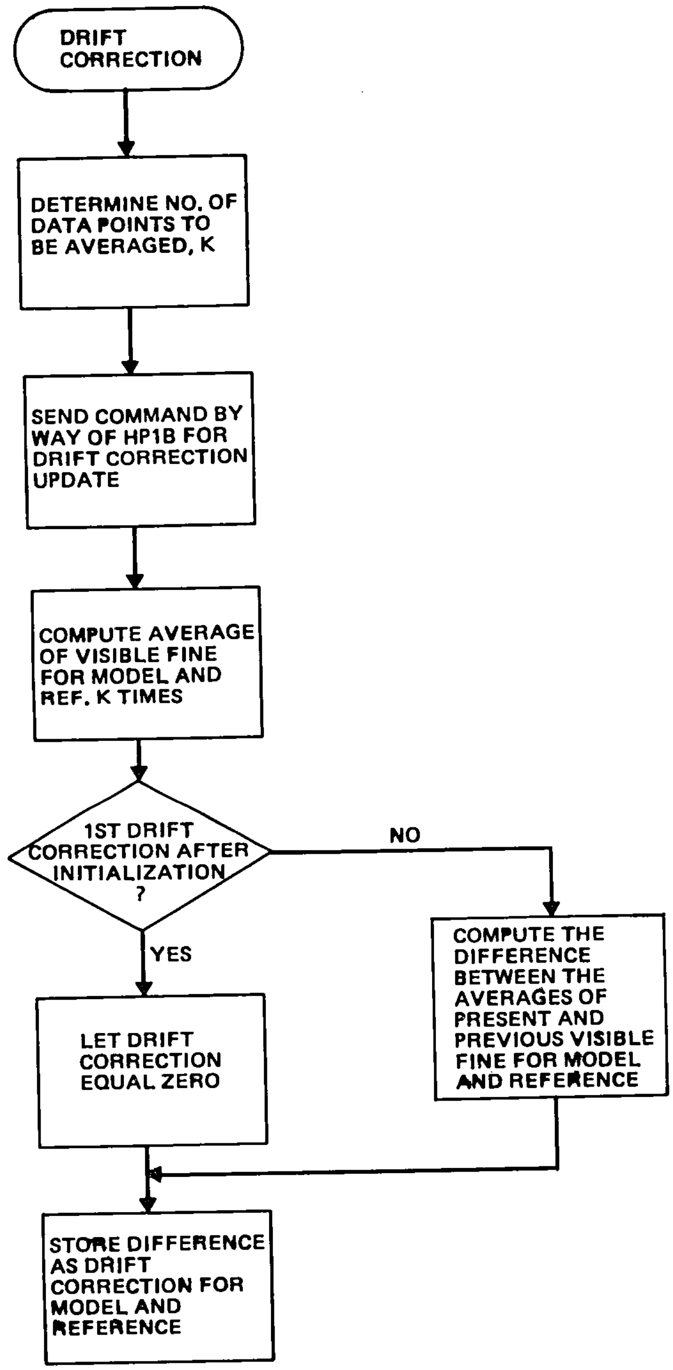

8B
USE MODEL CALIBRATION TABLE TO OBTAIN TRUE MODEL $\angle\theta$
N = Ncal
INPUT DATA BLOCK
TEST SIGNAL PRESENCE ?
NO
8A
DRIFT CORRECTION AS NECESSARY
TRUE MODEL $\angle\theta$
N = Ncal + RELATIVE COARSE + VISIBLE FINE + DRIFT CORRECTION FOR MODEL AND REF
OUTPUT MODEL AND REFERENCE TRUE MODEL /


STORE DATA IN DATA TABLE
10B
INPUT DATA BLOCK
NO
SIGNAL PRESENT ?
SUBTRACT VISIBLE FINE FROM I.R. FINE FOR MODEL
TEST DIFFERENCE TO DETERMINE IF DISCONTINUITY INTERVAL
CORRECT FOR DISCONTINUITY IF APPLICABLE
DETERMINE FINE BIN LOCATION FROM MODEL VISIBLE FINE DATA
0 (M)
N = ?
1(M)
INCREMENT NO. OF DATA ENTRIES FOR RESPECTIVE BIN-LOCATION IN TABLE 0M POINTD TO BY FIN BIN LOCATION
INCREMENT NO.'S OF DATA ENTRY FOR RESPECTIVE BIN-LOCATION IN TABLE 1M POINTED TO BE FINE BIN LOCATION
USE NO. OF DATA ENTRIES AND FINE BIN LOCATIONS AS POINT FOR STORAGE LOCATION FOR DIFFERENCE
USE NO. OF DATA ENTRIES AND FINE BIN LOCATIONS AS POINT FOR STORAGE LOCATION FOR DIFFERENCE
SUBTRACT VISIBLE FROM I.R. FOR REFERENCE
DETERMINE FINE BIN LOCATION FROM REFERENCE VISIBLE
TEST DIFFERENCE TO DETERMINE IF DISCONTINUITY INTERVAL
CORRECT FOR DISCONTINUITY IF APPLICABLE
10A

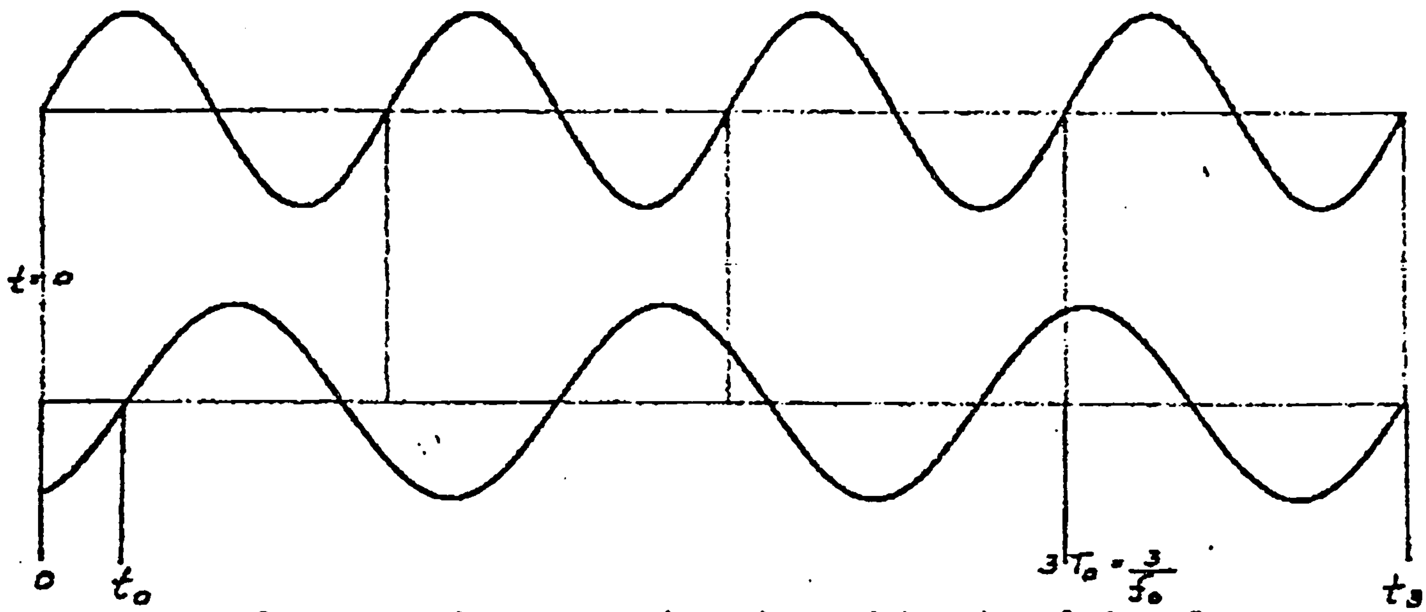

10 A
N = ?
0 (R)
1 (R)
INCREMENT NO. OF DATA ENTRIES FOR RESPECTIVE BIN LOCATION TABLE 0R POINTED TO BY FINE BIN LOCATION
INCREMENT NO. OF DATA ENTRIES FOR RESPECTIVE BIN LOCATION TABLE 1R POINTED TO BE FINE BIN LOCATION
USE NO. OF DATA ENTRIES AND FINE BIN LOCATIONS AS POINTERS FOR STORAGE LOCATION
USE NO. OF DATA ENTRIES AND FINE BIN LOCATIONS AS POINTERS FOR STORAGE LOCATION
SCAN COMPLETE ?
NO
10 B
YES
CORRECT DATA FOR DOPPLER SHIFT
DETERMINE ABSOLUTE COARSE FOR MODEL AND REFERENCE



$$\left.\frac{W_o + W_d}{W_o}\right|_N = \frac{1}{1 + \frac{C_{N+1} - C_{N-1}}{6000}} = \frac{1}{1 + \frac{C_N - C_{N-1}}{3000}}$$


DRIFT CORRECTION
DETERMINE NO. OF DATA POINTS TO BE AVERAGED, K
SEND COMMAND BY WAY OF HP1B FOR DRIFT CORRECTION UPDATE
COMPUTE AVERAGE OF VISIBLE FINE FOR MODEL AND REF. K TIMES
1ST DRIFT CORRECTION AFTER INITIALIZATION ?
NO
YES
LET DRIFT CORRECTION EQUAL ZERO
COMPUTE THE DIFFERENCE BETWEEN THE AVERAGES OF PRESENT AND PREVIOUS VISIBLE FINE FOR MODEL AND REFERENCE
STORE DIFFERENCE AS DRIFT CORRECTION FOR MODEL AND REFERENCE

The equations for the doppler frequency shift correction.



Let t = 0 at a certain zero-crossing-going-positive time of the reference clock signal which then has the formula

$$S_0 = A_0 \sin(w_o t)$$

The visible and infrared signals reflected back from the model (or reference) retroreflector are

$$S_v = A_v \left[\sin w_o t + w_d(t)\, t + w_d(t)\, K_v + A_v(\alpha)\, \alpha + \beta_v(t)\right]$$

$$S_I = A_I \left[\sin w_o t + w_d(t)\, t + w_d(t)\, K_I + A_I(\alpha)\, \alpha + \beta_I(t)\right]$$

Their frequencies $f_o + f_d$ differ from the clock frequency f_o because of the doppler frequency f_d which is the same for both channels. There are three phase shifts: $w_d K$ because the signals are shifted from the center frequency of the band pass filter, $A\alpha$ which is the phase shift due to the direction angle of the retroreflector and β which is due to signal delays through the system.

A counter clock runs at a rate of 1000 counts per reference clock period.

$$\Delta t = \frac{1}{1000\, f_o}$$

The reference clock signal has zero-crossing-going-positive times of

$$t = \frac{2\pi M}{w_o}$$

with M any interger.

The visible and infrared signals have zero-crossing-going-positive time of

$$t = \frac{2\pi N - w_d K - A\alpha - \beta}{w_o + w_d}$$

with N any integer.

The counts measured by the start-stop counter for the visible and infrared channels for $M = N = 0$ are

$$C_{VO} = \frac{t_o}{\Delta t} = 1000\ f_o\ t_o = -\frac{1000\ f_o(w_d K_V + A_V \alpha + \beta v)}{w_o + w_d}$$

$$C_{IO} = -\frac{1000\ f_o(w_d K_I + A_I \alpha + \beta_I)}{w_o + w_d}$$

The measurements are taken every three cycles of the reference clock. The counts measured by the start-stop counter for the visible channel for $M = N = 3$ are

$$C_{V1} = \frac{t_3 - 3T_o}{\Delta t} = 1000\ f_o\ \left(\frac{2\pi 3 - (w_d K_V + A_V \alpha + \beta v)}{w_o + w_d} - \frac{2\pi 3}{w_o}\right)$$

Subtracting gives

$$C_{V1} - C_{V0} = 1000\ f_o\ 2\pi 3\left(\frac{1}{w_0 + w_d} - \frac{1}{w_o}\right) = -\frac{3000\ w_d}{w_o + w_d}$$

which can be used to solve for the doppler frequency shift. Using the infrared channel would give the same result.

$$\frac{C_{V1} - C_{V0}}{3000} + 1 = 1 - \frac{w_d}{w_o + w_d} = \frac{w_o}{w_o + w_d}$$

so that

$$(K_V - K_I)w_d + (A_V - A_I)\ \alpha + \beta_V - \beta_I =$$

$$(C_{I1} - C_{V1})\ \frac{2\pi(w_o + w_d)}{1000\ w_o} = \frac{(C_{I1} - C_{V1})\ 2\pi 3}{C_{V1} - C_{V0} + 3000}$$

and the doppler frequency shift is corrected for. When a symmetrical expression is used with $C_{V,\,N+1}$ and $C_{V,\,N-1}$ there is a choice of using

$$\frac{1}{\left\{\frac{w_o}{(w_o + w_d)}\right\}\text{average}} \quad \text{or} \left\{\left(\frac{w_o + w_d}{w_o}\right)\right\}\text{average}$$

to give

$$(K_V - K_I)\, w_d + (A_V - A_I)2 + \beta_V - \beta_I$$

$$= \frac{(C_{IN} - C_{VN})\; 2\pi\; 3}{\frac{C_{V,\,N+1} - C_{V,\,N-1}}{2} + 3000}$$

or

$$= \frac{(C_{IN} - C_{VN})\; 2\pi\; 3\left(\frac{C_{V,N+1} - C_{V,N-1}}{2} + 3000\right)}{(C_{V,\,N+1} - C_{V,\,N} + 3000)(C_{V,N} - C_{V,N-1} + 3000)}$$

respectively. For small doppler shifts both expressions give approximately the same value.

VII. COMPONENT PARTS LIST

PARTS LIST

IC's	Quantity	Manufacturer
LF-356 BN	55	
LM-741 CN	4	
LM-747 CN	1	
Lm-311 N	1	
LM-358 N	1	
LH-0021 CK	1	
MC-3447 P	2	
DS-8820 AN	1	
DS-8830 N	1	
SN74LS00N	4	
SN74LS02N	2	
SN74LS04N	20	
SN7406N	1	
SN74LS08N	3	
SN7409N	1	
SN74LS10N	3	
SN74LS14N	5	
SN74LS20N	2	
SN74LS73N	1	
SN74LS74N	9	
SN74121N	1	
SN74LS154N	2	
SN74LS157N	2	
SN74LS192N	18	
SN74LS193N	31	
SN74LS221N	10	
SN74LS241N	12	
XR2208	5	
XR8038	5	
D8748	1	Intel
P8291A	1	Intel
DAC-169-16D	1	Datel Intersil Inc.
TIL-216 (LED)	4	Texas Instruments
TIL-111	4	Texas Instruments
ML3001	1	Mitsubishi Electronic Corp. ALGaAs Laser Diode
UDT-500	5	United Detector Tech.
OE-58 (2.7 MHz)	1	International Crystal Manufacturing Co. Inc.

PARTS LIST

Transistors	Quantity	Manufacturer
2N2905	5	
2N2222	3	
2N4300	1	
2N3735	2	
2N2920 (NPN-PNP)	5	
2N4858 (FET)	5	
Transformers		
SP-67	21	Triad
DOT-23	1	TRW
Votage Regulators		
LM340LAZ-12	5	
LM320L-12	5	
LM309H	6	
LM320T-12	1	
Power Supply's		
85-15-2150	1	Sola
LYS-X-15	1	Lambda
LUS-9-12	2	Lambda
ECV-12DI.T	1	ACDC electronics
Thermoelectric Cooler		
FCO.6-18.06L	1	Melcor Inc
Thermister		
GB34J14	3	Fen Wall
Controller		
63911	2	Controller Research Inc.

PARTS LIST

Misc.	Quantity	Manufacture
Motor	1	TRW Globe
Motor Rotating Lens 75A120-2, A.C. Synchronous Type FC 60Hz 115 volts, sync speed 1800 RPM	1	Arrow Electronics
KRP11DG 12 V.D.C. Relay	2	Potter & Brumfield
PRMA1A05	1	Clare Relay
5VK3F2581 Line Filter	2	CorCom
MPD-6405-6 Electromechanical Actuator 12 V.D.C motor 6 in. travel	1	Duff-Norton Co.
PBS2107F1-1000	1	PeWee Boxer Fan
Heaters		
HK6070-0J.B54	4	Minco Products Inc.
HK6070-08B86.4	2	
HK6070-10B108	2	
HK6060-07B52.3	4	
HK6060-12B89.6	4	

PARTS LIST

	Quantity	Manufacturer
Cylinder Lens #23-7503 300 mm focal length 60 mm long, 50 mm wide	1	Ealing Corp.
Filter #26-4457 RG-715 glass	1	Ealing Corp.
Mirror #41,802, Gold coat, 127x178 mm	1	Edmond Scientific
Mirror #71,709, Gold coat, 203x254 mm	1	Edmond Scientific
5-inch Lens, 24.75-inch FL #3E1475, coated	1	A. Jaegers
Right angle prism #39E2023 silvered & coated, 17x12x12 mm	2	A. Jaegers
Fused silica window optical grade 4000 3½ x 9 inches, 3/4 inch thick, commercial polish both sides, Magnesium Fluoride AR coat centered at 7000 Angstroms, both sides	1	Esco Products Inc.
Fused silica window same as above but 3-inch diameter & 3/4 inch thick	1	Esco Products Inc.
Fused silica window optical grade 4000 2-inch diamter, ½ inch thick commercial polish both sides no AR coating	2	Esco Products Inc.

PARTS LIST

	Quantity	Manufacturer
Cube corner reflector diameter = 0.245 +0, -004-inch height = 0.174, +0, -0.004-in to sharpe edge, max. bevel allowed= 0.010-inch, $\lambda/4$ surface flatness 30 arc second or less beam deviation apex concentric to diameter to within 0.010-inch, make from Schott SF56 Grade A, precision annealed optical glass	6	Rocky Mountain Instr. Co.
Interference filter FWHM=30Å+3nm width = 1¼ inch, height = 3/8 inch, thickness less than or equal to ¼ inch, clear aperture = 1x¼ inch, blocking from 0.3 to 1.1 microns, center wavelength = 633 nm	2	Dell Optics
Lens, #33B 3006, plano-convex lens, FL = 7.6 mm, diameter = 4.5 mm coated	90	A. Jaegers

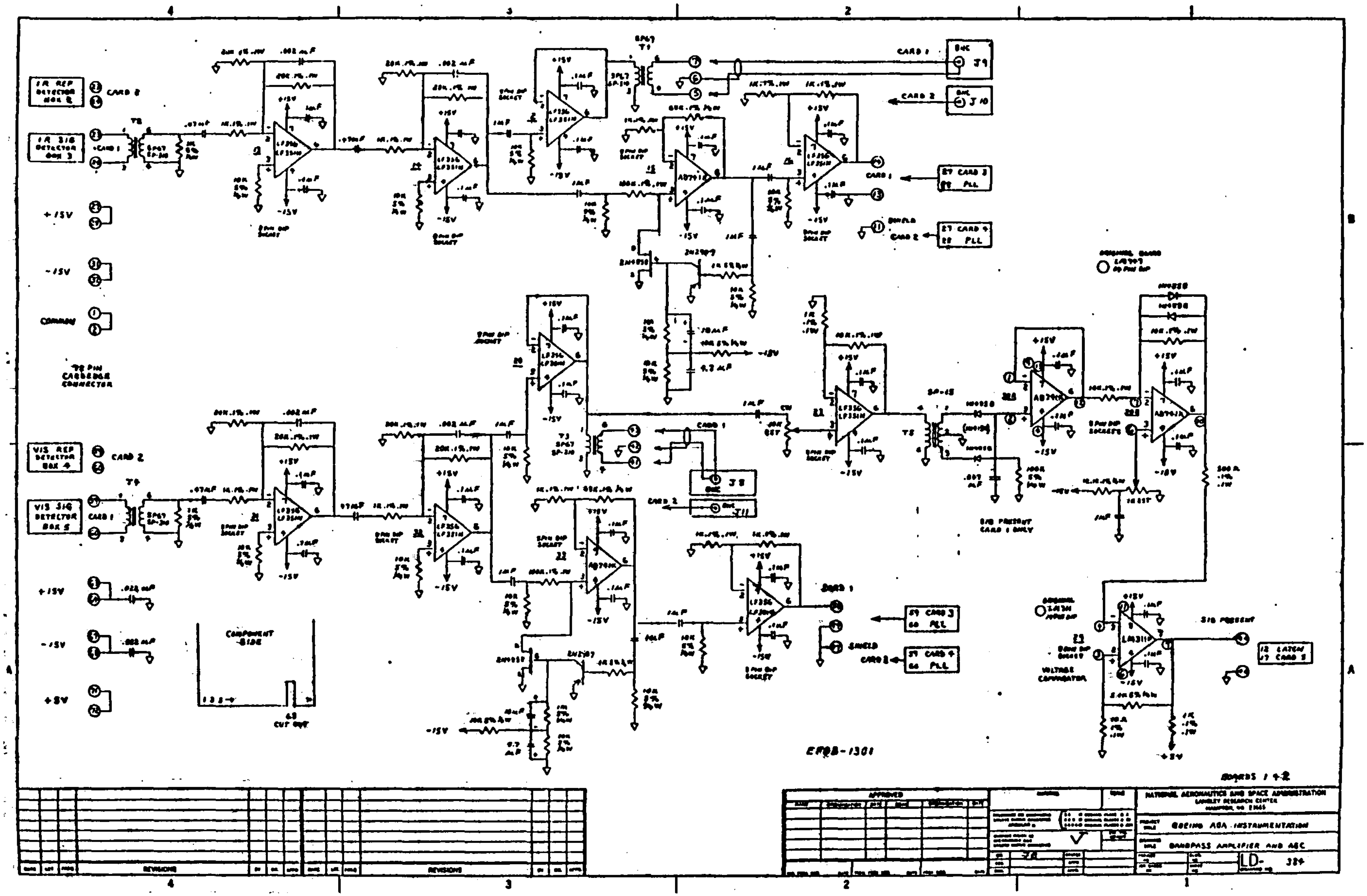
VIII. REFERENCES

1. Marks, Lionel S., Mechanical Engineers Handbook, pp. 477-480 (McGraw-Hill Book Co., New York, 1941).

2. Smakula, A. et. al., Harshaw Optical Crystals, p.16 (Harshaw Optical Company, 1967).

3. Faupel, Joseph H., Engineering Design, p.244 (John Wiley and Sons, Inc., New York, 1964).

IX ADDENDUM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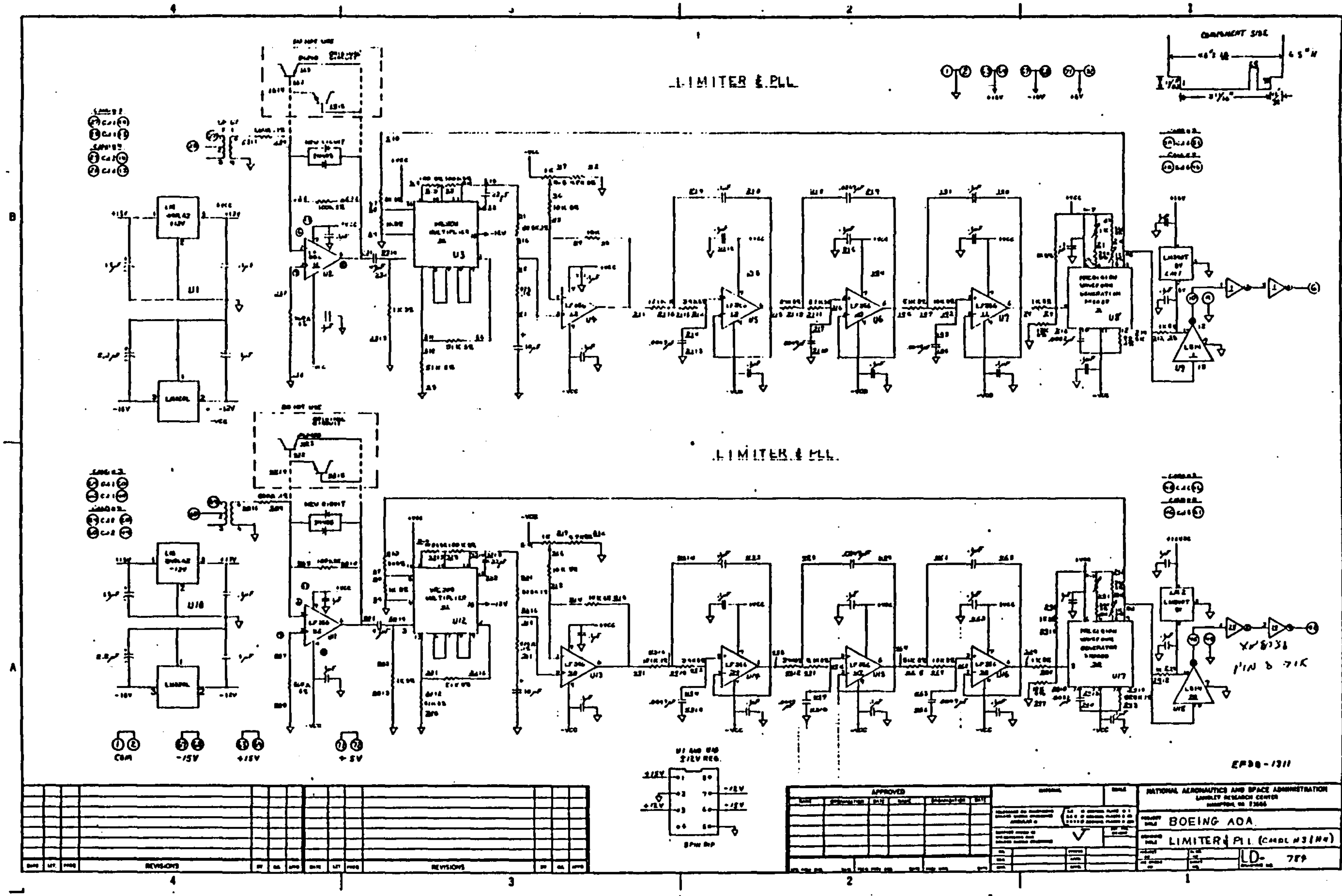
IR SIG DETECTOR BOX 3
VIS REF DETECTOR BOX 4
VIS SIG DETECTOR BOX 5
+15V
-15V
COMMON
+5V
COMPONENT SIDE
CUT OUT
SIG PRESENT
VOLTAGE COMPARATOR
EF8B-1301
BOARDS 1 + 2
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
BOEING ADA INSTRUMENTATION
BANDPASS AMPLIFIER AND AGC
REVISIONS
APPROVED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LIMITER & PLL
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-15V
+15V
+5V
U1 AND U10
±12V REG.
8 PIN DIP
XN8136
PIN 5 71K
EP36-1311
REVISIONS
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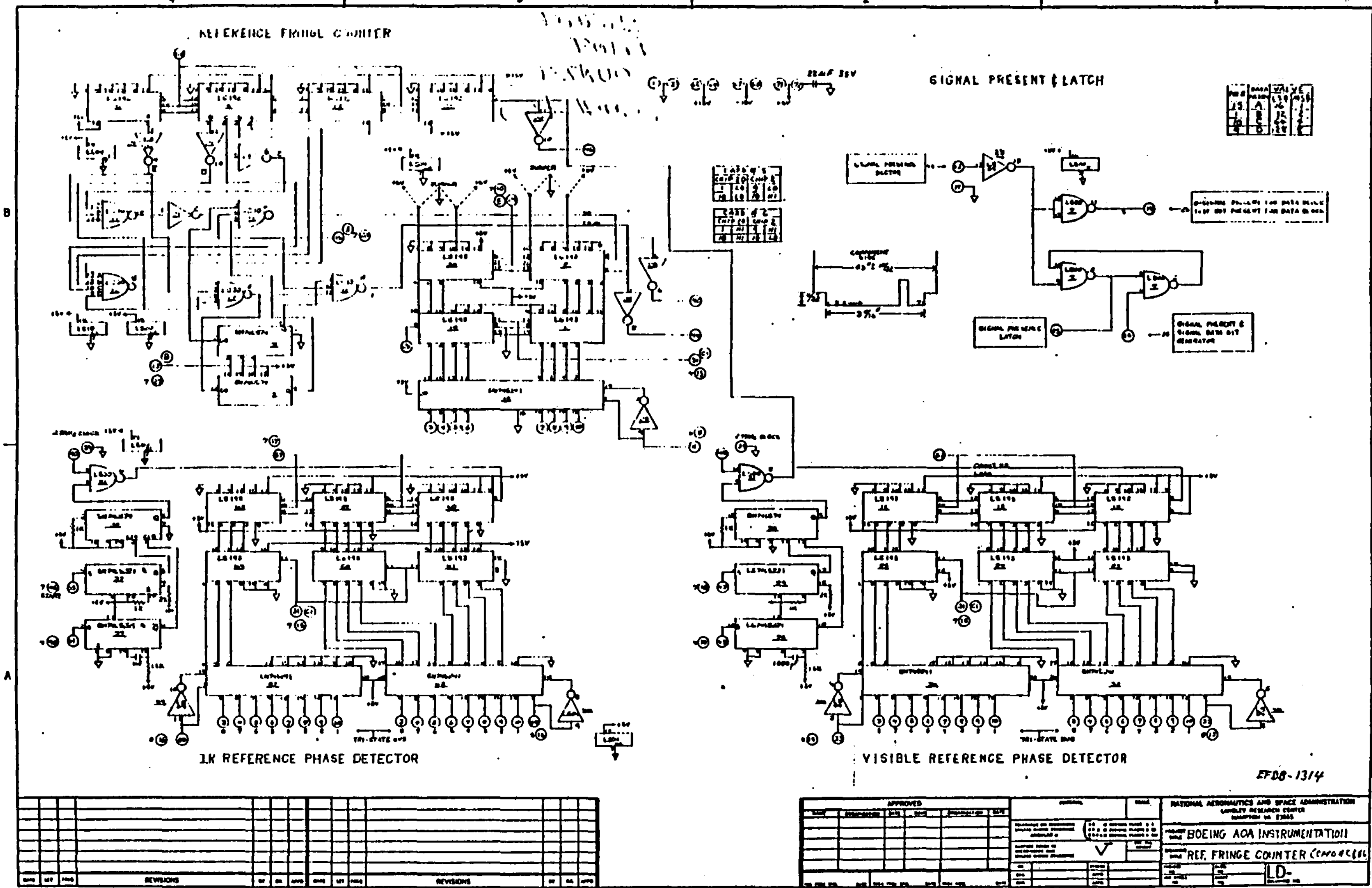
BOEING ADA
LIMITER & PLL
LD- 789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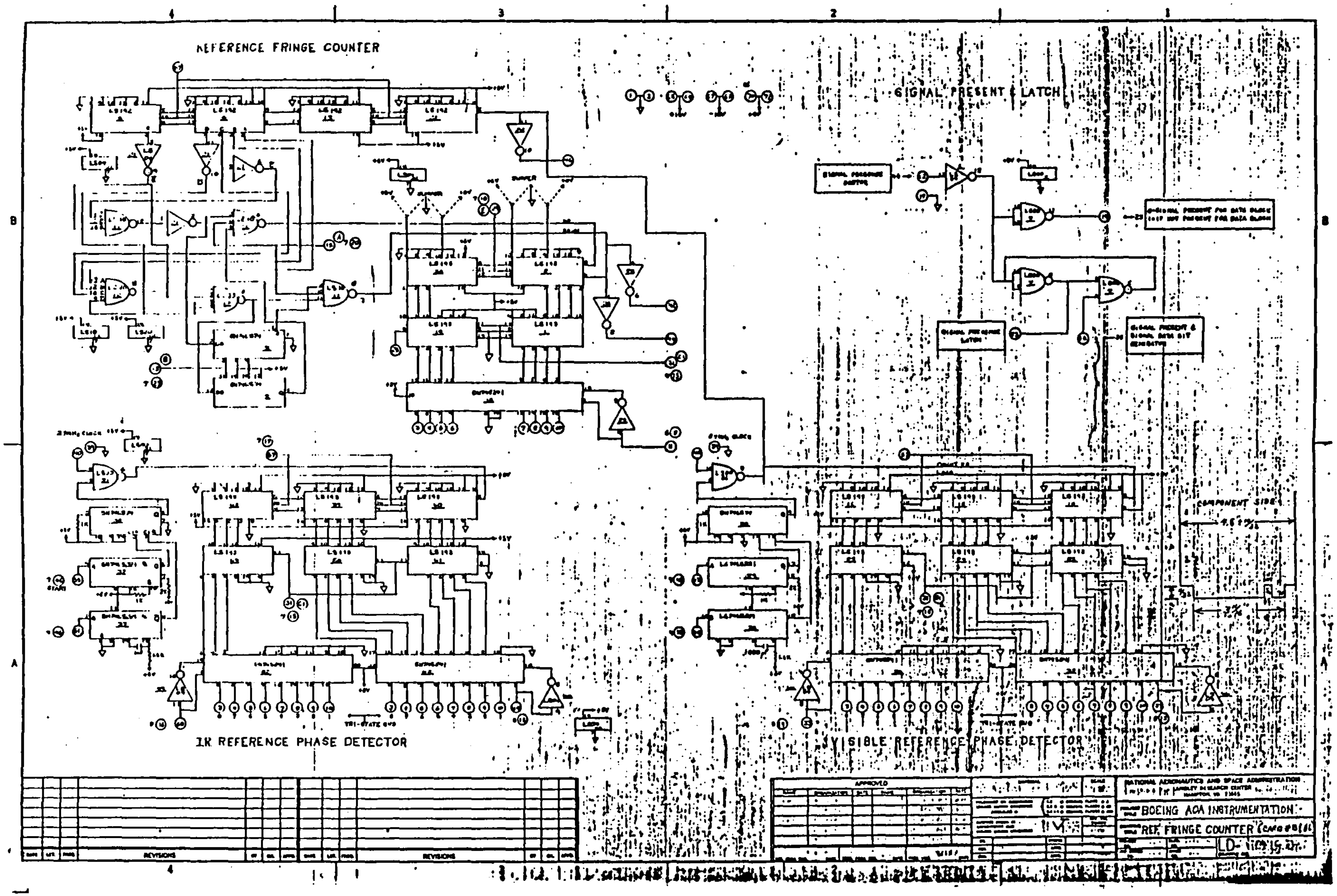
VISIBLE REFERENCE PHASE DETECTOR
EFD8-1314
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
BOEING AOA INSTRUMENTATION
REF. FRINGE COUNTER
LD-
REVISIONS
APPROVED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COMPONENT SIDE
BOEING AOA INSTRUMENTATION
REF. FRINGE COUNTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
REVISIONS
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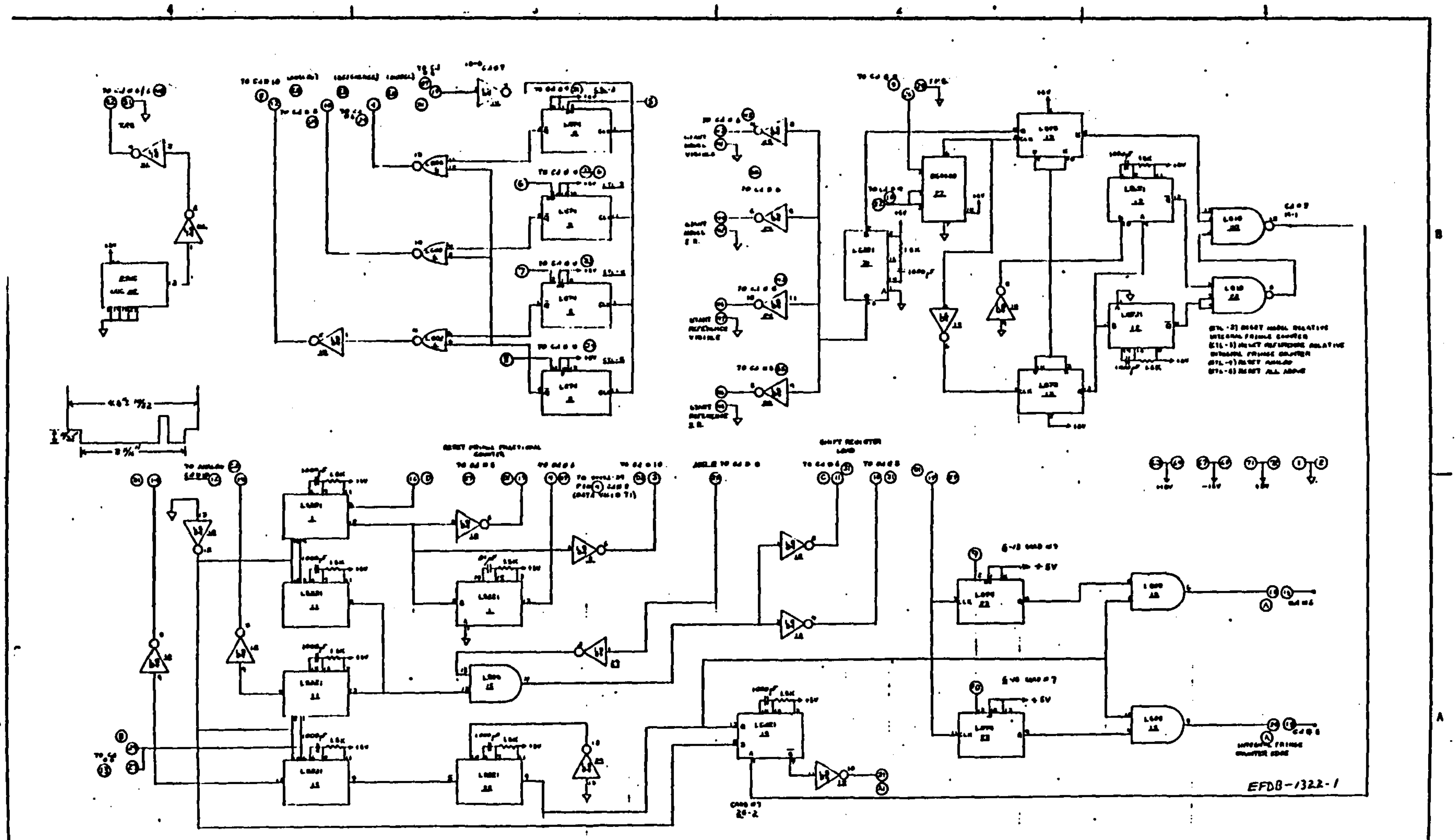

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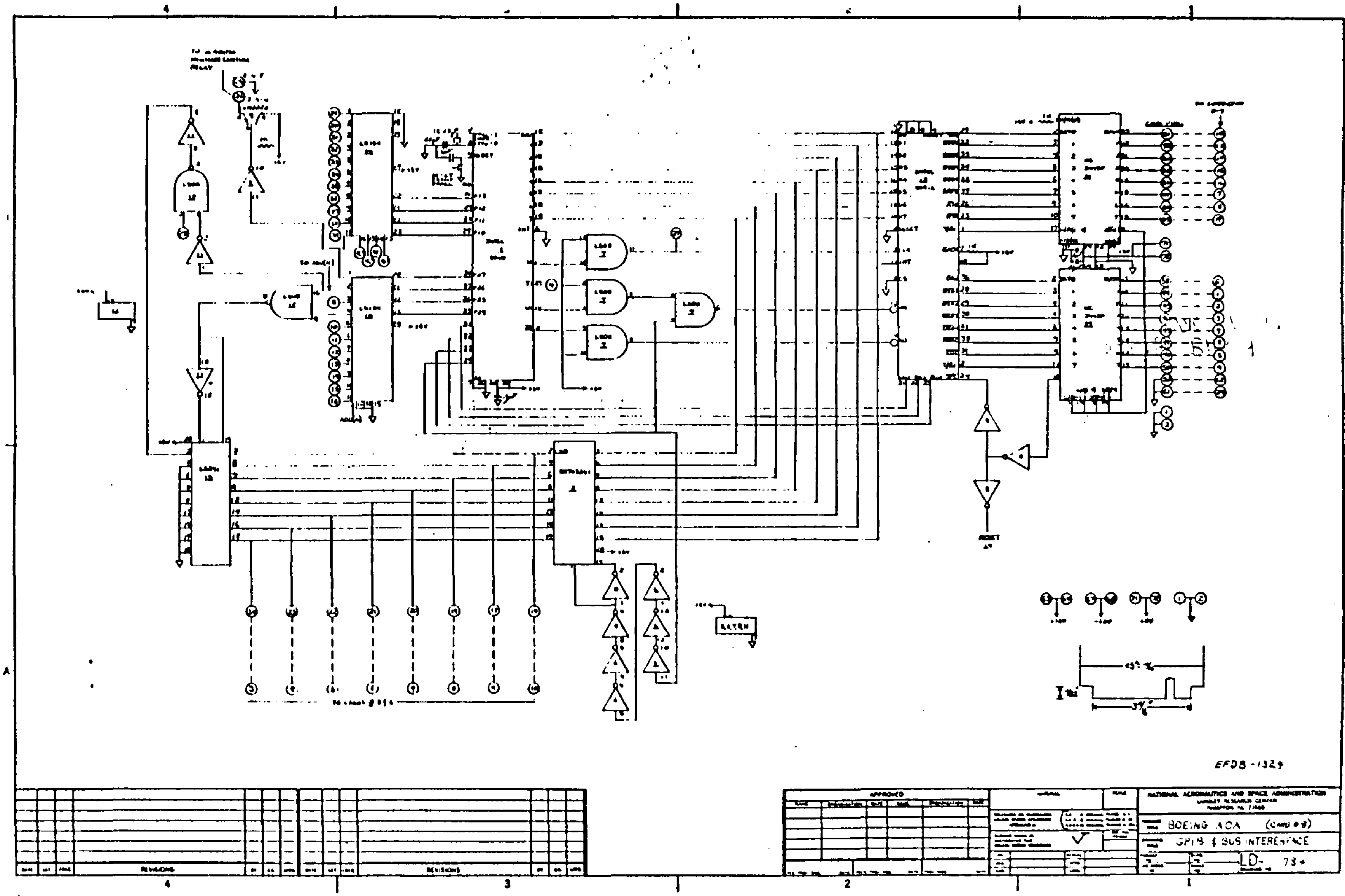
HAMPTON VA 23665

BOEING AOA

TIMING GENERATOR(CARD #7)

LD-



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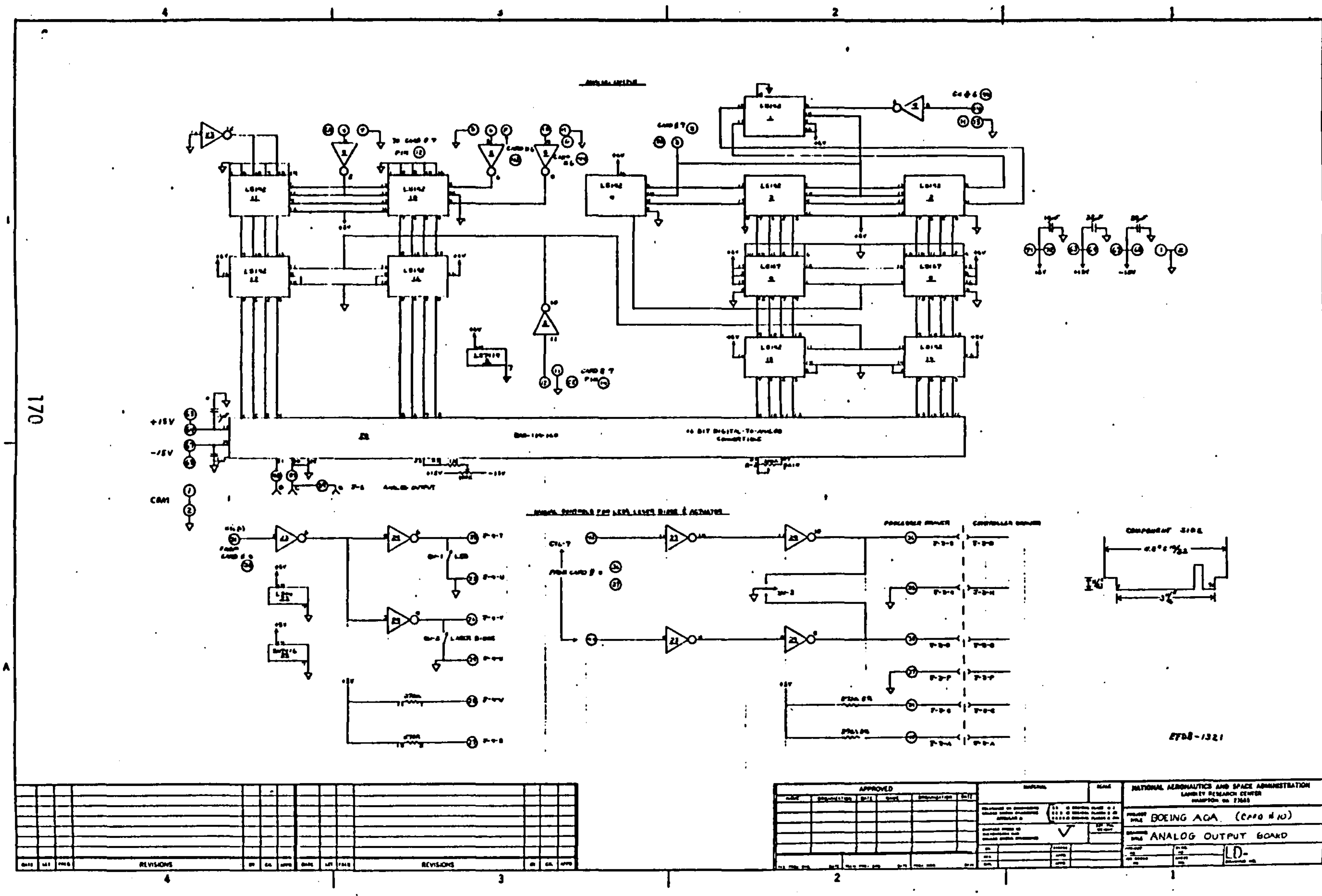
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-15V
COM
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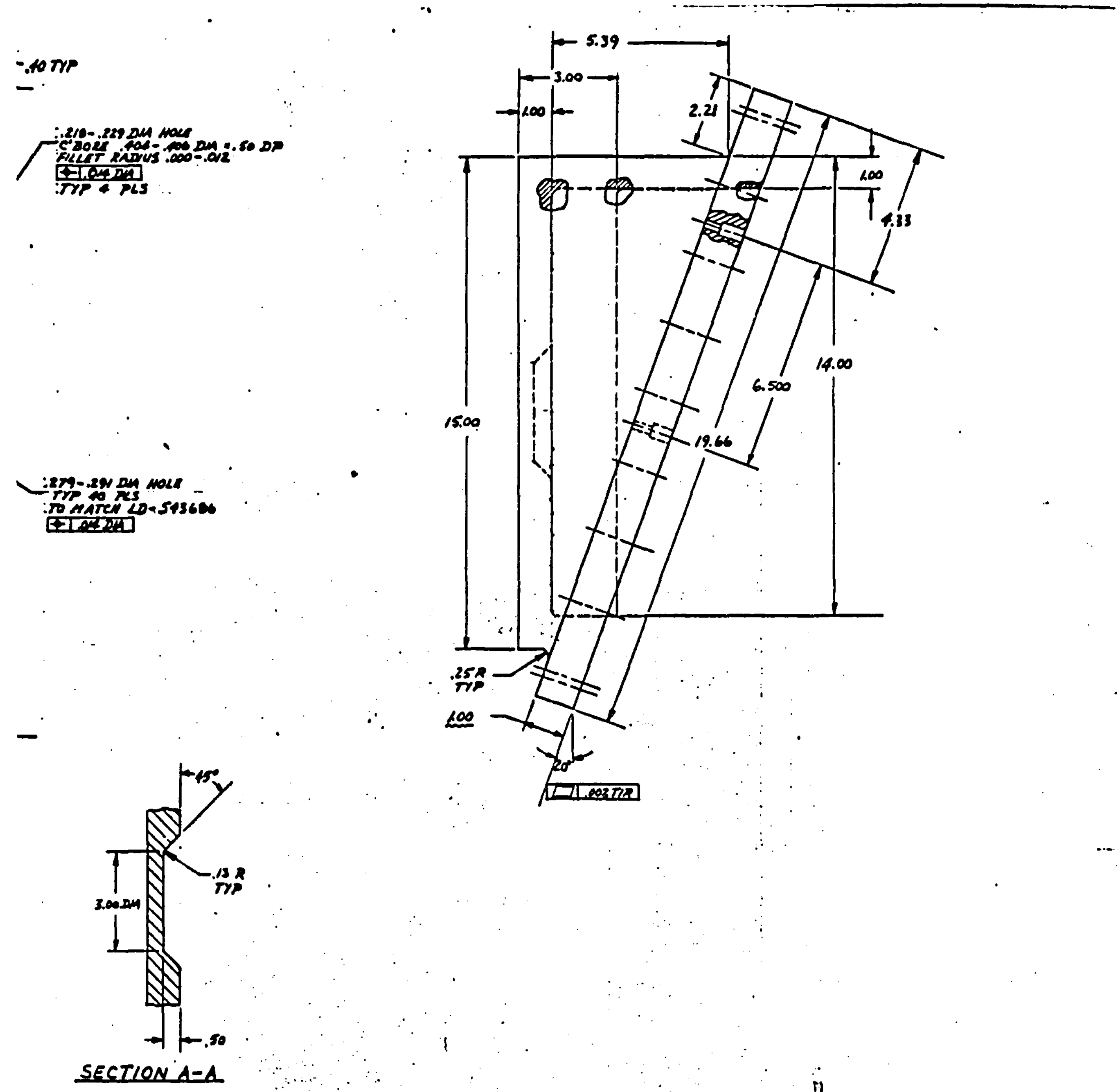
BOEING AGA (Card # 10)
ANALOG OUTPUT BOARD
LD-



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QTY REQD	FSCM NO.		PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL / SPECIFICATION	ITEM NO.

PARTS LIST

Aerospace Technologies Division
3221 North Armistead Avenue
Hampton, Virginia 23666

NAS1-18000

APPROVED					
NAME	ORGANIZATION	DATE	NAME	ORGANIZATION	DATE
Glihn	MEC	7/31/85			

MATERIAL: SEE P/L

ANGULAR ± ½°

125

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VA. 23665

PROJECT TITLE: NTF-LASER PACKAGE ENCLOSUR

DRAWING TITLE: DETAIL RP-014-1

JOB ORDER NO. 210969

LD-543684

NOTES

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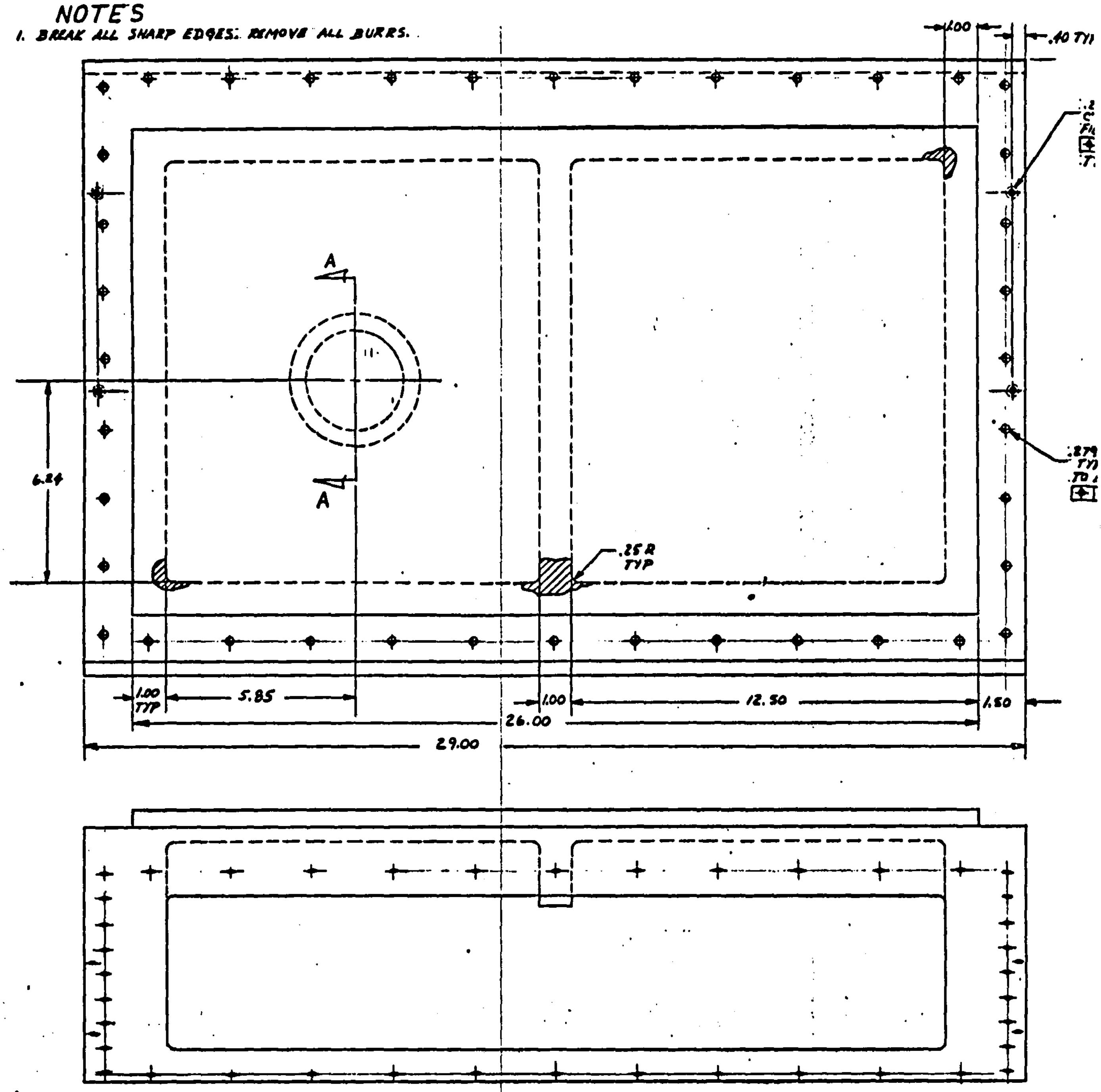

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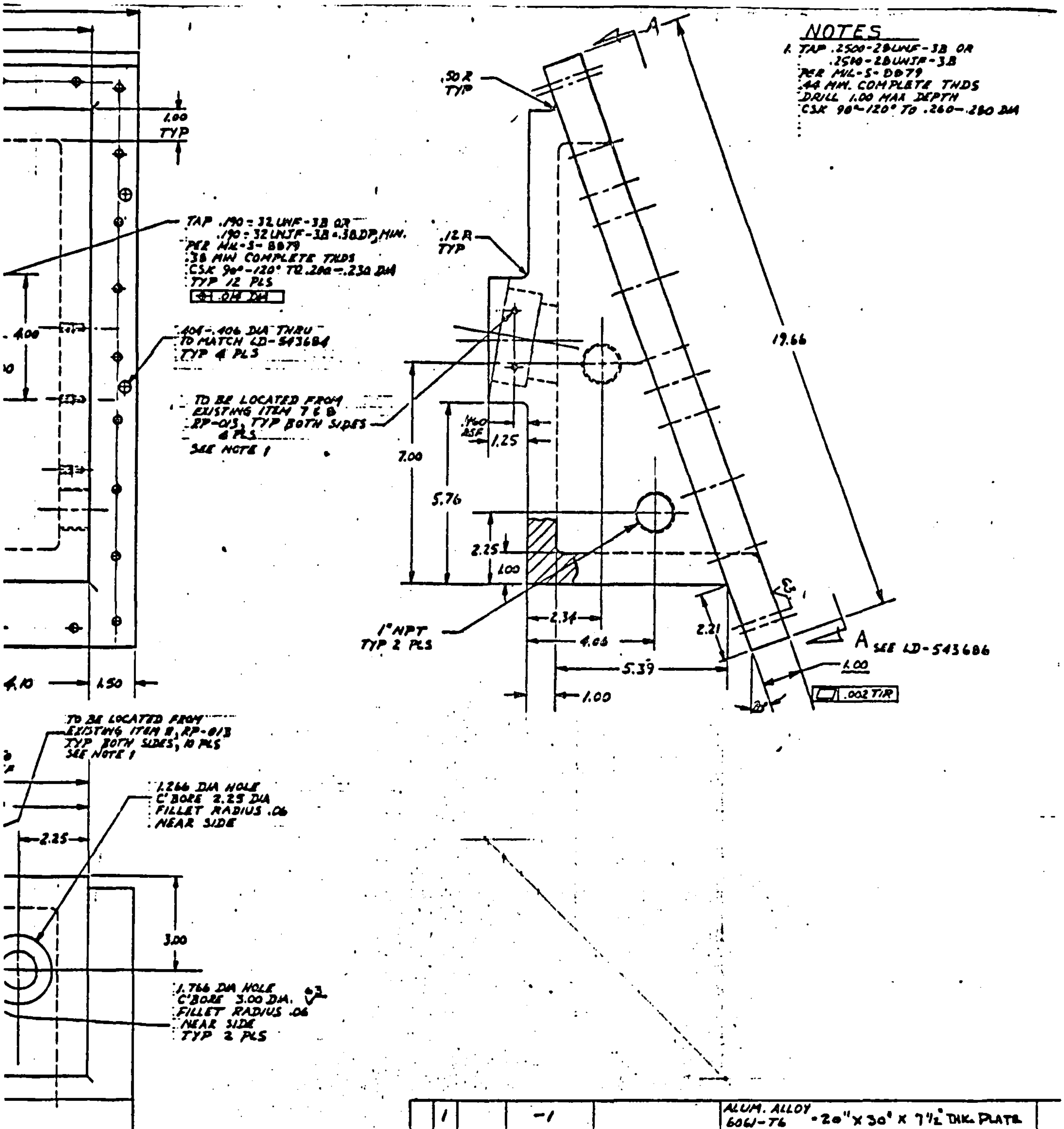
Kentron International, Inc.

LD-543684

H-159

DR. H. SCHWEITZER 5-85



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PARTS LIST

173

Aerospace Technologies Division
NAS1-18000

APPROVED: DWG/ME MES 7/14/?

MATERIAL: SEE P/L

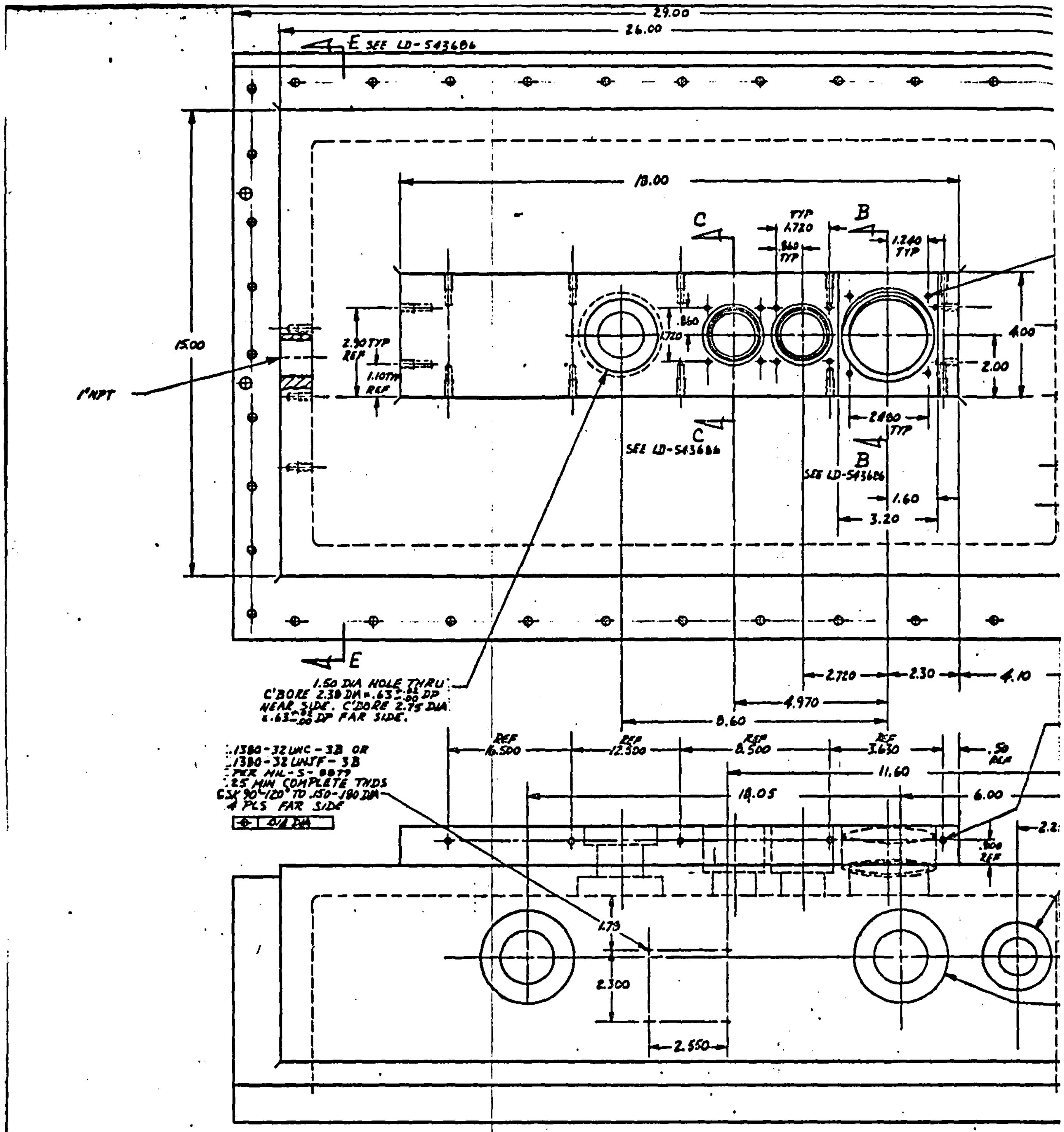
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VA. 23665

PROJECT TITLE: NTF-LASER PACKAGE ENCLOSURE

DRAWING TITLE: DETAIL RP-014-2

JOB ORDER NO. 10969

LD-543685



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Kentron International, Inc.

LD-543685

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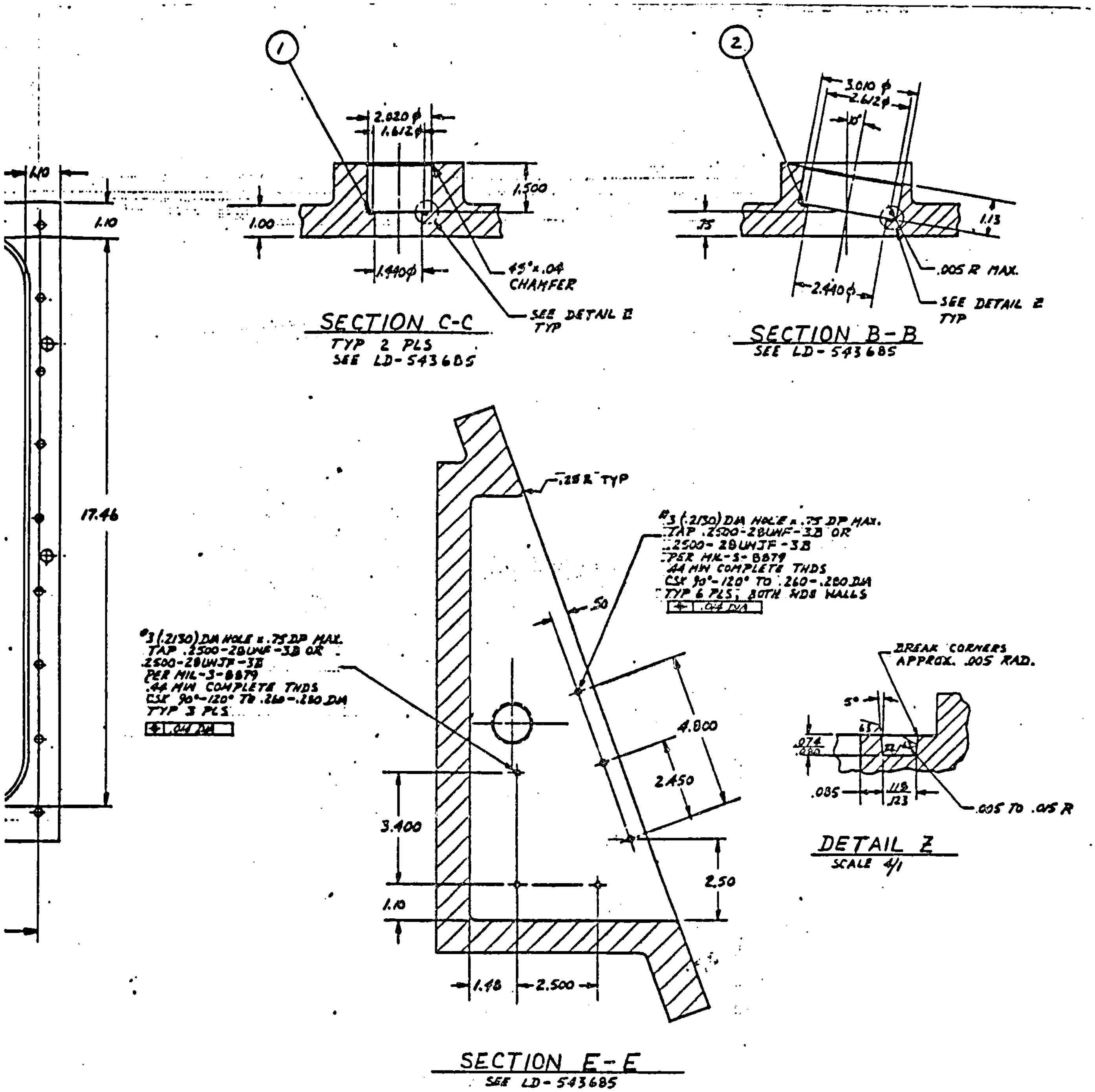
DR. H. SCHWEITZER 5-85



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	2	-1	O-RING	.103 CROSS-SECTION x 1.612 ID NITRILE, SHORE A 70

PARTS LIST

175

American Technologies Division
3201 North Armistead Avenue
Hampton, Virginia 23666

NAS1-18000

NASA REF.

APPROVED: Name: Gwinn — Organization: MBS — Date: 7/10/81

MATERIAL: SEE P/L

TOLERANCE ON DIMENSIONS UNLESS OTHERWISE SPECIFIED: ANGULAR ± 1°

SURFACE FINISH: 125

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VA. 23665

PROJECT TITLE: NTF-LASER PACKAGE ENCLOSUR.

DRAWING TITLE: RP-014-2 DETAILS

JOB ORDER NO. 210969

DRAWING NO. LD-543686

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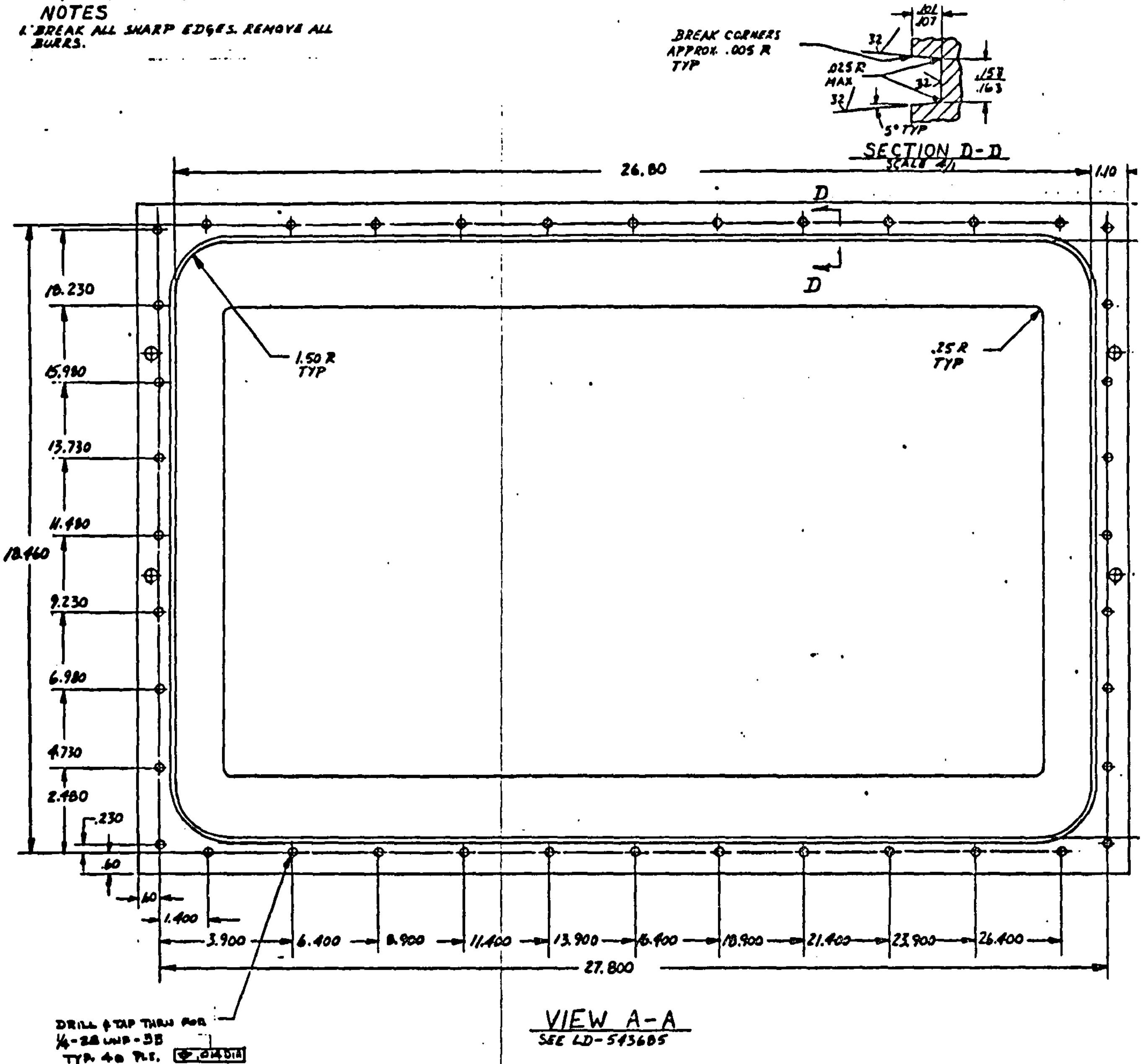

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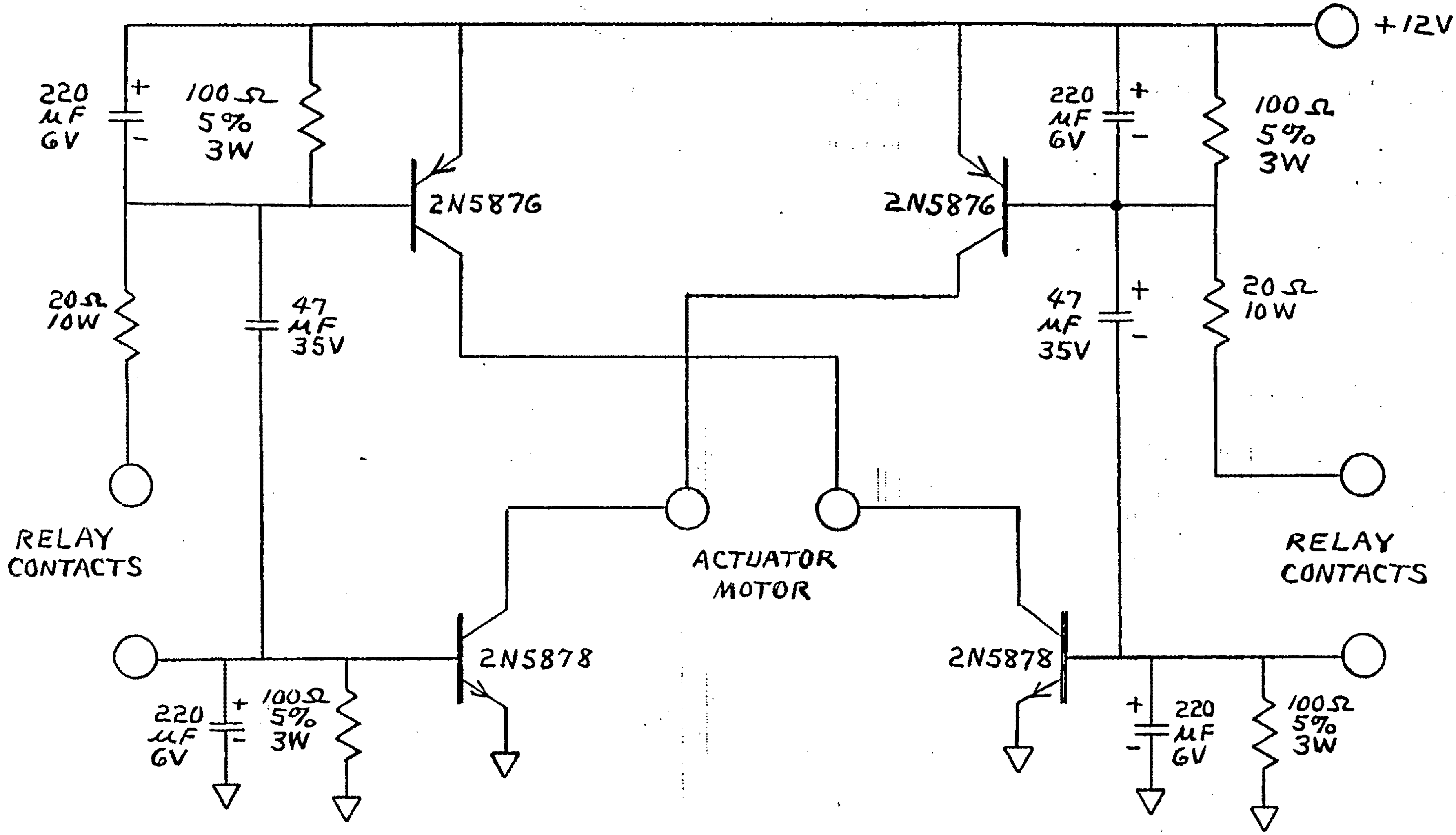
LD-543684

H-159

W. SCHWEITZER

CATES



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EFDB-1373

NOTE: USE SOLDER TERMINALS.

FB 12/31/84

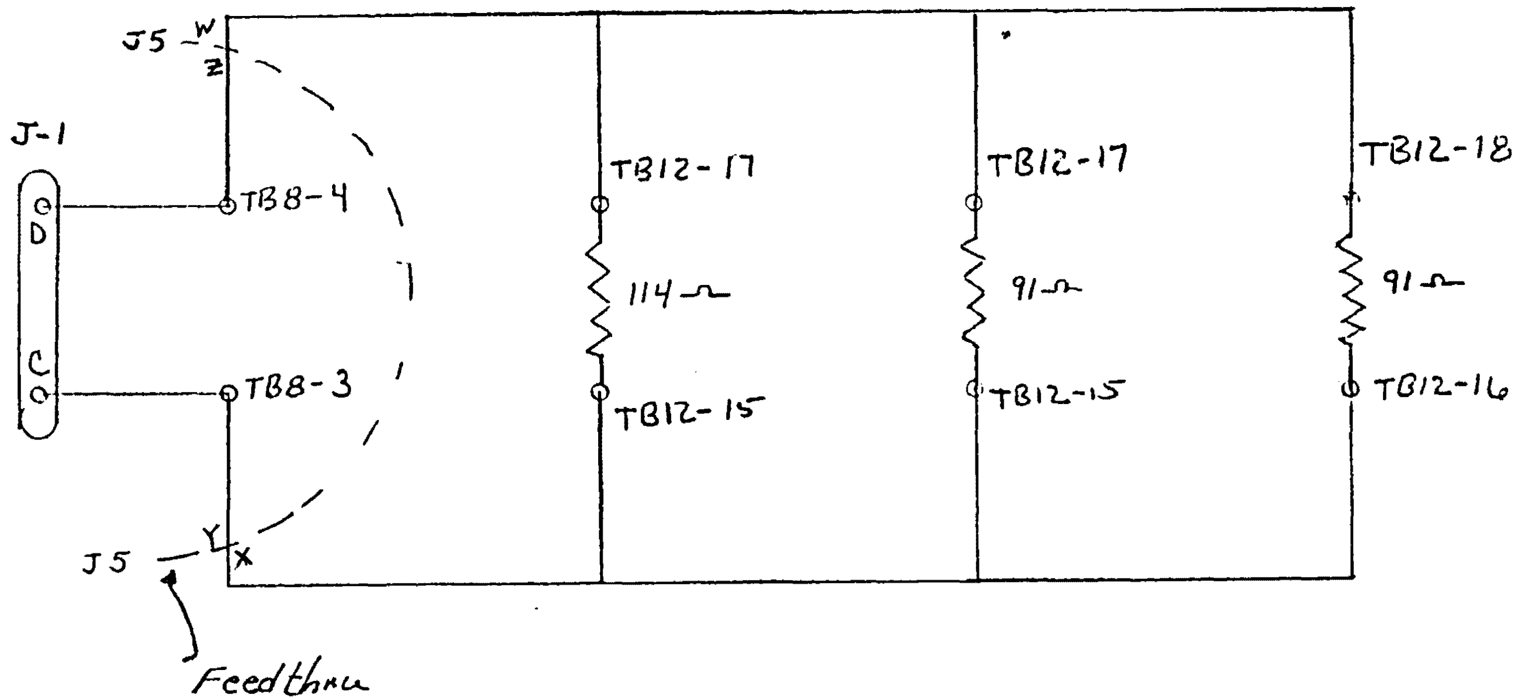

Figure 48: Heaters, Lower Unit

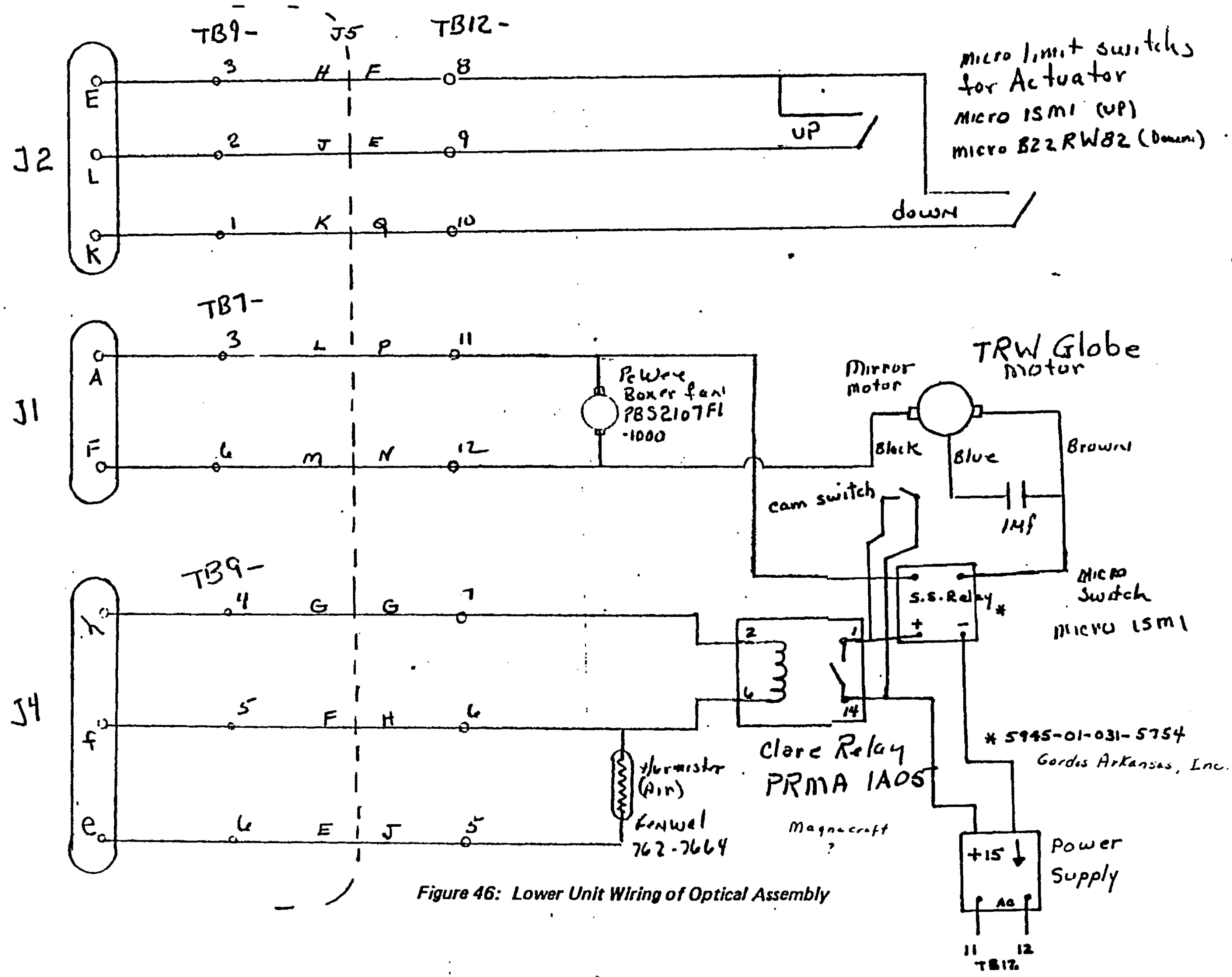

Figure 46: Lower Unit Wiring of Optical Assembly

Standard Bibliographic Page

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		6. Performing Organization Code
7. Author(s) C. R. Pond and P. D. Texeira		8. Performing Organization Report No.
9. Performing Organization Name and Address Boeing Aerospace Company P. O. Box 3999 Seattle, WA 98124		10. Work Unit No.
		11. Contract or Grant No. NAS1-16546
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		13. Type of Report and Period Covered Contractor Report
		14. Sponsoring Agency Code 505-31-53-09

15. Supplementary Notes

Langley Technical Monitor: Tom D. Finley

16. Abstract

A laser angle measurement system was designed and fabricated for NASA Langley Research Center. The instrument is a fringe counting interferometer that monitors the pitch attitude of a model in a wind tunnel. A laser source and detector are mounted above the model. Interference fringes are generated by a small passive element on the model. The fringe count is accumulated and displayed by a processor in the wind tunnel control room. This report includes optical and electrical schematics, system maintenance and operation procedures.

17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Angle measurement Wind tunnel instrumentation Interferometry	Unclassified - Unlimited Subject Category 09

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	183	A09

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